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THE RAILWAYS OF THE FUTURE.

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Many persons in England are apt to suppose that we have come to the end of railway extension. The country is so well furnished with railways, and their financial results are so disappointing, that people are naturally loth to contemplate any further experiments on the established system. We are most grateful to the shareholders who have been so good as to supply us with these admirable roads, which have gone far to change the character of our civilization; but there are not many of us who care to follow their example, and we cannot be surprised if they should themselves be unwilling to continue the sacrifice of their fortunes for our benefit. Still, those who are acquainted with the demand for railways in foreign lands, in our colonies, and even in many parts of our own country, must be aware that we are speaking literally when we say that railways are as yet but in their infancy. There is an enormous demand for them in India, for instance; and yet every man of common sense must admit that, judging by all English examples, it is perfect madness to construct them on the received system, which means ruinous expenditure and dead loss. So thoroughly is the need of a great revolution in railway construction perceived, that some months ago we had to make the startling announcement that the Governor-General of India, dissatisfied with the slow progress and excessive cost of railways in his dominion, had actually sent to the United States for engineers who might confer with him as to the introduction of a more effectual and economical system—as if this were beyond the capacity of English engineers; and we propose now to give some account of further most important investigations tending to the same result as that so earnestly desired by Lord Mayo, whose conclusions, it may be mentioned in passing, coincided substantially with those formed independently by the Duke of Argyle at home.

It may be well to begin by reminding our readers that in October last (the 19th and 20th) we gave a pretty full account of what is known as the Fairlie system of railway working*—a system by which lines of the lightest construction and very narrow gauge may accomplish work hitherto deemed within the means only of lines of ponderous construction and broad gauge, and by which also the established lines of standard gauge may either partly diminish expenses, or, without additional cost, well nigh double their carrying capacity. The characteristics of the system will appear in the sequel; for the present we proceed to state that Mr. Power, the vice-chairman of the Poti and Tiflis Railway Company (a railway of 330 versts in the Caucasus), and Mr. Crawley,

* See pages 380, 540, 543, and 593, Vol ii. of this magazine.

the contractor for its construction, were so struck with the merits of the Fairlie system, that they strongly recommended its adoption to the Russian Government, not only for the line prepared in the Caucasus, but also for all lines throughout that vast empire, where railways are of prime necessity, and where now, according to the new plan, 5 miles can be provided at a cost which was swallowed up in 3 miles, according to the old one. The recommendation carried the greater weight, inasmuch as the works of the Poti and Tiflis Railway were far advanced, and on a length of 15 versts the rails are actually laid down. The proposition, therefore, was that the Russian Government would find their advantage, even on these conditions, of changing the plans on which so much work had been expended, taking up the rails which have been laid down, and constructing the line on a gauge of 2 ft. 6 in., or exactly half the standard Russian gauge. The Minister for Public Works, Count Bobrinskoy, seized upon the idea. Mr. Fairlie went to St. Petersburg to explain his scheme in detail; and the result of all is that an Imperial Commission has been sent over to this country to inspect the actual working of the system in various places, but chiefly on a wonderful little railway of 2-ft. gauge in Wales.

The chief of the Commission is Count Alexis Bobrinskoy, cousin to the Minister of Public Works. He is accompanied by a considerable staff of engineers, foremost among whom may be mentioned Professor Saloff, of the Russian Imperial Institute; and Mr. Roehrberg, the manager of the most successful railway in Russia; and by personal friends, as Count Camoyski and Count Alexander Berg, who take an interest in the question of railways. At the same time Mr. Fairlie offered to the Indian Government the opportunity of witnessing the experiments to be instituted for the Russian Commissioners; and they, being themselves anxious for the means of improving and economizing their own railway system, at once resolved to take advantage of the offer. They appointed a Commission, consisting of Lieutenant-General Sir William Baker, R.E., and a member of the Council of India; Mr. Thornton, Secretary of the Public Works Department in the India Office; and Mr. Danvers, Government Director of Indian Railway Companies, to accompany the party. Captain Tyler also, the Government Inspector of Railways, who has already reported favorably on the Festiniog Railway of 2-ft. gauge, attended on behalf of the Board of Trade, and Mr. Pihl, Chief Engineer of Railways in Norway, was present on the part of the Norwegian Government. Besides these gentlemen, who went to witness the trials officially, others took an interest in the various proceedings in a private capacity; chief among them being the Duke of Sutherland and Count Béla Széchenyi, son of the Hungarian patriot of that name, who was well known in England some 30 years ago. The Duke took an especial interest in the inquiry, as he is not only a director of the North Western Railway Company, but is himself the proprietor of a considerable length of railway on his Sutherlandshire estates.

The party thus constituted started off on Thursday morning last in a special train of saloon carriages, and halting at Crewe, to view the magnificent works of the North Western Railway—the largest in Europe, with the exception of those at Creuzot, in France—proceeded by Shrewsbury into Wales. At Welshpool they entered upon the Cambrian Railway system, and, with the advantage of brilliant weather, were conducted by Mr. Elias through the very picturesque country, up hill and down dale and round curves of hill-sides, by which the line passes to Portmadoc. At Portmadoc is the terminus of the line known as the Festiniog Railway, of 2-ft. gauge (really 1 ft. 11½ in.), which was the principal subject of investigation.

The Festiniog Railway, which is pronounced by no less an authority than Captain Tyler, the Inspector of Railways, to be the most instructive line in the three kingdoms, and which seems destined by its success to give a new impulse to railway engineering, is itself one of the oldest in existence. The Act for it was obtained in 1832, but in the first instance it was constructed only for horse traction. It is a single line, 13¼ miles in length, with a branch of one mile connecting the slate quarries of Festiniog with the quays of Portmadoc. The terminus of Festiniog has 700 ft. of elevation above that at Portmadoc, the average gradient being 1 in 92, which is enough to secure the

descent of the trains on the return journey from Festiniog to Portmadoc by the impetus of gravitation, or, as the Welshman puts it, "by its own impittence." The line runs through a rude, rocky country, and has to adapt itself to an endless variety of curves along the contour of the hills, so that a train of any length has frequently to wriggle in serpentine fashion along 2 or 3 reverse curves, some of them sharp enough—the radius being 1¾ chains. On these curves the cant or super-elevation of the outer rails is never more than 3 in. The line, in the old days when it was worked by horses, was originally laid with rails of 16 lbs. to the yard. When, about 8 years ago, it was adapted to the locomotive, it was fitted with rails of 30 lbs. to the yard, most of which have been in use ever since. These, however, were found too light for the work, and are now being replaced by double-headed rails of 48½ lbs. to the yard. The wheels of the carriages being less than 2 ft. apart, it is found convenient to arrange most of those for passengers after the fashion of an Irish car, with footboard overhanging the wheels. In this way the carriages are so low hung, and even carriages of the ordinary build are so near the ground in consequence of the small diameter of the wheels, that the expense of platforms at the stations is avoided. The whole expense of constructing and reconstructing the line, including tunnels, one of them 700 yds. in length, with branch lines to the slate company's inclined planes and the quays at Portmadoc—in all, 14 miles—has been £75,000, or at the rate of £5,378 a mile. The value of the rolling stock on the line is £28,000, or at the rate of £2,000 a mile. And now comes the most important point of all, which is that the original capital of the company is £36,185, and that all the extra money which has been laid out upon the line has been taken from revenue. In this sense, therefore, as the net revenue of the company is £10,622, it appears that the line yields a dividend of 29½ per cent. on the original capital. A sum of £50,000, however, paid out of revenue for improvements and reconstructions, has been capitalized—making the total capital £86,185. In this sense the net revenue of the line yields a dividend of 12½ per cent. Whichever way the fact is to be stated, it is a most remarkable one, and must fill many a shareholder's heart with envy.

The chief cause of this wonderful result is the narrowness of the gauge, which has enabled the Festiniog Company to economize in many ways. Thus, for example, the trucks for goods or minerals, even when fully loaded, have less of dead weight on a narrow than on a broad gauge. The best wagons on the standard gauge of 4 ft. 8½ in. are reckoned to weigh 7 cwt., and to carry 12½ cwt. of pig-iron or coal for every foot of their length, the dead weight being in the proportion of 56 to 100 of the *maximum* paying load, or 36 per cent. of the entire load. On the other hand, the wagon for a three-feet gauge is calculated to weigh 2½ cwt., and to carry 8 cwt. for every foot of its length, the dead weight in this case being a very little over the proportion of 31 to 100 of the *maximum* paying load, and under 24 per cent. of the entire load. But there is still another view from which it can be shown that the wagons for goods and minerals on a line of a narrow gauge are not so disproportionate in weight to the weight carried as they are on the broad gauge. In goods traffic it is well known that the dead weight of a train is enormous—something like 70 or 80 per cent. of the total weight hauled. If goods are to be delivered on a long line of railway, they are in this country arranged in many more wagons than are necessary to hold them, because a goods wagon cannot, like a passenger carriage, unload itself, and the train cannot wait till the unloading at a particular station is finished. It has to pass on, leaving the wagon of goods for that station behind, and it is more than probable that for this purpose the wagon has been but half or a quarter loaded. This becomes serious when wagons that weigh several tons carry but a fraction, often a small fraction, of their own weight. Such a source of expense disappears to a large extent on a narrow-gauge line, where the wagons are comparatively small, and it is but one example of the saving which may be effected in the working of such a line, in addition to the saving of cost of construction in the first instance.

This remark would hold good of the narrow gauge in itself and worked according to the ordinary system; but it is in

the working of the Fairlie system that the greatest saving of all is effected, and it is mainly, indeed almost entirely, in consideration of the economy, the increased power, and the diminished wear and tear which this system implies, that a much narrower gauge than that now in general use has begun to find favor in the eyes of practical men. It was long before the Festiniog Railway Company could get an engineering firm to undertake to build a locomotive for a line of such steep gradients, combined with sharp curves, which they could guarantee. At last Messrs. George England & Co. undertook the task, and supplied engines which worked with perfect success, and then people began to believe in a railway of narrow gauge. One of Mr. Fairlie's engines has now been built for the line; it is called the Little Wonder, as the other engines which have preceded it have been called the Welsh Pony, the Little Giant, as well as by other diminutive names; and the result has so surpassed expectation in the power it exerts, in its gentleness of action, in its economy of fuel, in its saving of the rails, and in its adaptation to troublesome curves and gradients, that for the first time practical men have discovered that a gauge of 2 ft. 6 in., or of 3 ft. at the very utmost, is enough for the heaviest traffic. It is no secret that two engineers of eminence, Mr. Fowler and Mr. Fairlie, have pronounced a 3 ft. gauge to be ample for all the requirements of India, and there were men of position in the party which went down to Wales, men with characters to lose, who made what seems to us the hazardous statement that on a gauge of even 2 ft. 6 in. they would undertake, with the Fairlie engine, to work the heaviest traffic in the world—that of the London and North Western Railway. Be that as it may, it must be strange for those who can remember the battle of the gauges to find that what was then known as the narrow gauge is now in its turn attacked as being much too broad, and is even described in the terms which have been applied to more than one scheme of the Brunels as a gigantic folly. Our 4 ft. 8½ in. gauge is now established in so many countries—it is used not only in Great Britain, but also in France, Belgium, Switzerland, Italy, Austria, Prussia, Denmark, Egypt, the Cape of Good Hope, Australia, the United States, and Central America—that we seem to think of it as a standard of perfection. In some countries there will be found a still broader gauge—as in England itself, in Ireland, in the United States, in Canada, in Australia, in India, in South America, in Portugal, in Spain, in Russia; but in very few will a narrower gauge be found. In England we have 14 miles on a 2 ft. gauge, and a few more on a slightly broader gauge; in Belgium there is a 3 ft. 8 in. gauge; in France, a 3 ft. 4 in. gauge; in India may be found a 4 ft. gauge; and in Norway and Sweden one of 3 ft. 6 in.; on the Mont Cenis Railway there is a 3 ft. 7½ in gauge; and in Queensland one of 3 ft. 6 in.; and now we have opinion tending towards a gaugeof 2 ft. 6 in., or of 3 ft., as the standard for the future.

It is easy to determine on light railways of narrow gauge, and to construct them. The difficulty is to work them, and to work them in such a manner that their capacity and their economy shall bear comparison with railways of larger design and more elaborate construction. Hitherto railways of light construction and narrow gauge—that is, narrower than 4 ft. 8½ in.—have been in little favor, because of the limited power and destructive effects of the locomotive. Take, for example, the oscillation. This is very destructive on the standard gauge; it is, indeed, the chief cause of destruction to the permanent way—a fearful item of expense. But it is still worse on a narrow gauge, and necessitates diminished speed on battered rails. Therefore, practically, a narrow gauge was but of limited application to ordinary traffic until a locomotive, such as that of Mr. Fairlie, could be invented free, or nearly free, from oscillation. And again, since a narrow gauge generally implies lightness of construction, and since lightness of construction implies sometimes roughness of workmanship, and nearly always such an adaptation of the railway to the surface of the country that it must dispense to a great extent with cuttings, viaducts, and other works, and must be ready to accept to the fullest extent possible a line of sharp curves and heavy gradients, it was necessary to devise a locomotive for it capable of good and safe speed on these conditions; and there was none such of sufficient note in existence until the double-bogie engine of Mr. Fairlie was produced,

which combined great size and power with freedom from oscillation, and with a short wheel base that could be worked round curves of 60 ft. radius and even less.

We cannot be wrong in saying that there was an absolute unanimity of opinion among all those who have witnessed the working of that narrow gauge railway at Festiniog, that the standard gauge of 4 ft. 8½ in. is far beyond all ordinary requirements. There may be some difference of opinion as to the precise gauge which is best. Mr. Spooner, the engineer of the Festiniog Railway, strongly advocated a gauge of 2 ft. 6 in., and he was supported in this view by practical men of great experience; others seemed to hold that a gauge of 3 ft., giving greater freedom of space, would be best, but all appeared to be convinced that a gauge much narrower than that now in general use is capable of work which is at present little imagined in the railway world. If this view be correct, it involves some most important results. Thus, let us take an ordinary line costing £15,000 a mile, and compare it with one of narrow gauge worked on the new system, with power of carrying equal paying loads, and costing, as we have already indicated, three-fifths of the price of the other—namely, £9,000. With a traffic return of £20 every week for every mile, and deducting 50 per cent. for working expenses, the one railway would yield a dividend of about 3½ per cent., while the other would yield very nearly 6 per cent.; and this calculation makes no allowance for the more economical working of the narrow gauge, which is one of the main features of the system. If such a result be possible, it implies for public lines not a little encouragement to carry the railway system into every nook and corner of the kingdom where a moderate traffic may be obtained; and for Government lines the reduction of tariff to the lowest point.

There seemed to be a unanimity of opinion also as to the success of Mr. Fairlie's engine adapted to the narrow gauge, and also on the broad gauge; but it remains to be seen from the reports which will be furnished to the various governments, how far this unanimity extends. That the engine did some extraordinary work, is clear, as we shall presently show; but whether it is or is not to be recommended for adoption as a means of making the narrow gauge available to the utmost, is a point on which we have no information.

The object of the experiments on the Welsh railways was to ascertain whether or not the Fairlie engine increased the carrying capacity of a railway or diminished the cost of working it. With this view two engines were put on their trial—one, the Little Wonder, on the Festiniog Railway, of 2 ft. gauge, in North Wales; the other, the Progress, on the ordinary gauge of 4.8½, in South Wales.

The Fairlie engine consists of one long boiler, having two sets of tubes, with double fire-box between, and poised on two bogies. The arrangement is such that an enormously increased power is gained, with an extraordinary facility of movement upon swift curves, and with a freedom from oscillation which makes the Fairlie engine less destructive to the rails than locomotives of much less weight and power. The value of the system depends chiefly on the two bogies. It may be necessary to explain for some readers that a bogie is simply the name for a small truck. Instead of resting a wagon or a locomotive upon wheels of its own, which would make a long wheel-base that could not by any possibility get round very sharp curves, and that might get round moderate curves, but only with an amount of flange friction destructive to the rails and retarding speed, the wagon or locomotive is poised on two independent trucks, which have a short wheel-base, and which can, therefore, find little difficulty in curves of exceeding sharpness. In the small cabbage-garden at Hatcham, half-an-acre in extent, and laid out with rails of the ordinary gauge, Mr. Fairlie exhibits a steam carriage of 43 ft. in length, travelling at a speed of 25 miles an hour round curves of 50 ft. radius; and they could with equal ease, and even greater safety, travel round curves of 25 ft. radius, which is only about that of an ordinary engine turn-table. The engine, therefore, on a pair of bogies, is prepared for a circuitous line of country, even on the standard gauge, which engines of the current type could not attempt.

The excellence of the bogie, however, does not merely consist in its adaptation to curves. It has an extraordinary effect in reducing oscillation. An ordinary

carriage rests directly upon the ends of axles, and when, through any defect in the road, there comes a disturbance in the plane of movement, the carriage, wagon, or locomotive rocks from side to side with immense violence, in a series of oscillations that hammer the rails to their destruction. It is calculated that these oscillations, in a train going at the rate of 30 miles an hour, add more than half as much again to the normal weight upon the wheel, and this is very serious in the wheels of a locomotive, each of which may be loaded up to 7 or 8 tons. The oscillation is reduced to a *minimum* by means of the bogie, inasmuch as the vast superincumbent weight of the locomotive is balanced on a pin, called the bogie-pin, in its centre. The bogie is a flat table upon wheels, with a great pivot in the middle of it. This table, and the wheels which support it, must naturally submit to whatever deflections there may be in the road, and so far it is impossible to get rid entirely of oscillation; but the great mass of weight above being poised in the centre of the bogie, and upon the centre of the roadway, is comparatively free from the influence of rocking, and transmits little or no hammering to the rails. A child can understand this by watching at see-saw the difference between placing a weight in the middle of the plank and dividing it between the ends. Now, it is an enormous advantage thus to steady the locomotive, to reduce the tendency to oscillate, and to get rid of the violent impact upon the rails. To steady the locomotive is to make its motion safer, and to diminish the chances of its leaving the rails—a point of considerable importance on the narrow gauge. The most important point of all, however, is to save the rails, which are so perishable under the demands of a heavy traffic, that there are instances in which the strongest steel rails have to be replaced in six months. The rails, where the line has any curve, are torn up by the flange friction of monster engines, with an immense wheel-base, and, whether the line is curved or straight, are hammered out by the oscillations of the same engines. We have already explained how, in the Fairlie engine, the flange friction is reduced by the substitution of bogies, with a short wheel-base, for the old plan, which necessitates a long one, and there is an absolute unanimity of opinion as to the disappearance of oscillation with the use of the double bogie.

We have only one word more of preface before we proceed to state what were the experiments with the Fairlie engine, both on the narrow and on the broad gauge. It is that the statements we are about to make do not rest solely on our authority. The various Commissioners and other observers met together, under the presidency of the Duke of Sutherland, compared their notes point by point, and came to a perfect agreement as to the facts which they were prepared to vouch for. Our facts, therefore, have the authority of documents signed by the Duke of Sutherland, as chairman of the different meetings which were held; by the Russian Imperial Government; by the Commissioners of our Indian Government; by Captain Tyler, of the Board of Trade, who acted as secretary, and was mainly instrumental in putting the facts into proper form; and by others who were well able to judge.

The Little Wonder is an 8-wheeled double-bogie engine* of four cylinders 8 3-16 in. in diameter, with a stroke of 13 in. The diameter of its wheels is 2 ft. 4 in.; its average steam pressure is 150 lbs.; its weight is 19½ tons; its total length is 27 ft.; its total wheel-base is 19 ft., and the wheel-base of each bogie, which practically has alone to be considered, is 5 ft. This engine was first of all made to carry, from Portmadoc to Festiniog, a train made up of 90 slate-wagons, weighing 57¼ tons; 7 passenger carriages and vans, weighing 13½ tons, and 57 passengers, weighing 4 tons—in all, 75 tons. Add to this its own weight, and we have a total load of 94½ tons. The weight, it will be seen, was considerable, if we take into account the size of the engine, the narrowness of the gauge, the steepness of the gradients, and the sharpness and multitude of the curves. But the chief point of interest in this experiment had reference to the length of the train, which was 854 ft.—nearly the sixth part of a mile. A train of such a length on such a line had to run often upon two or three reverse curves, some of them with a radius as short as 1¾ chains, and it curled and doubled upon itself as it wound among

* See vol. 2, page 265.

the Welsh hills, so that the passengers in the front carriages could, sitting in their seats, make signals to the passengers in the hindmost ones. The engine, being in full gear, took this very long train up the hills, and in and out among the curves, at an average speed of 14½ miles an hour, and as a *maximum* speed of 26½ miles. Let us here add, by way of parenthesis, in order not to refer to it again, that some days afterwards a similar train, of 140 empty and seven loaded wagons, weighing in all 101 tons, and measuring in length 1,323 ft.—*that is, a quarter of a mile*—a train so long in fact, that there were parts of the road on which it had run on no less than five reverse curves—was by the same engine hauled up the hills at an average speed of 12½ miles, and a *maximum* of 16¼. Now, what was the result observed in wriggling along these curves? It was generally observed (we now quote almost *verbatim* from the protocol signed by the chief witnesses) that even on curves of 1¾ chains radius, and at *maximum* speed, there was very little perceptible oscillation or movement on the engine or in the carriages, and by no means such as is felt on comparatively easy curves on ordinary railways. Nor must this remarkable point be forgotten—a fact almost incredible, but yet certified by competent witnesses—*that the oscillation diminished as the speed increased.* The speed, let it be added, is naturally less on a narrow gauge than on a broad one. Captain Tyler, the Government Inspector of Railways, was at first so doubtful of the safety of a high speed, on a railway of such narrow gauge, and such wild curves, as that at Festiniog, that he insisted on limiting the company to a *maximum* speed of 12 miles an hour. Since then, however, his doubts have been so completely dispersed, that he has removed all restriction as to the rate of speed; and as a matter of fact the Little Wonder, when necessary, works up to 30 and 35 miles an hour.

Next day the oscillation of the Little Wonder was put to a further test, and compared with that of the other engines—the Welsh Pony and the Mountaineer—which are of the ordinary type. In this series of experiments the speed was confined to 10 or 12 miles an hour on a comparatively level line, the gradient being only 1 in 1,200; and the line was laid with rails weighing only 30 lbs. to the yard, and not fished at the joints. On the Welsh Pony and the Mountaineer, tank engines of the ordinary type, weighing, the one 10 and the other 8 tons, it was found that there was a strong vertical oscillation and a lateral oscillation not so strong. On the Little Wonder, the double-bogie engine weighing 19½ tons, it was found that when riding on the foot-plates there was no oscillation whatever, vertical or lateral, perceptible—only "a smooth floating movement;" and that when riding on the bogie frames there was felt a slight lateral oscillation, though less than on the other engines. It is added that, the oscillation of the Fairlie engine being confined to the bogie, the influence of impact on the rails from the flanges of the wheels was far less than in the case of the Welsh Pony and the Mountaineer, the whole weight of these engines being in the course of their oscillations brought to bear upon the rails.

Next followed some rather tedious but very interesting trials as to the comparative powers of the two classes of engine. The Welsh Pony was selected to represent the common type of engine. It is a four-wheeled locomotive, weighing 10 tons, with cylinders 8⅛ in. diameter, having a stroke of 12 in., and with wheels 2 ft. in diameter. It was in the first instance tacked on to a load of 50 slate wagons full of slate, weighing 123½ tons. To this add 3½ tons for passengers and 10 tons for its own weight, and we get at the entire load of 137 tons. With this the Welsh Pony started from Portmadoc, and, running along the comparative level (1 in 1,200) of the Traeth Mawr Embankment, stopped on a gradient of 1 in 85, unable to proceed further, with 160 lbs. to the square inch of steam pressure. Hereupon half the number of wagons was removed, and the load (including passengers and the engine itself) was consequently reduced to 72 tons 17 cwt. With this load it was found that the Welsh Pony could mount the gradient of 1 in 85 easily enough. Being successful with 25 wagons, the question arose, could it manage more? It was then tried with 30 wagons, but on the gradient of 1 in 85 it was found that it could not start, though, since the engine-wheels did not revolve, there was no lack of adhesion. Then again the load was reduced to 26 wagons, weighing (with

passengers and engine) 73 tons 16 cwt., and it was found that this was the limit of the Welsh Pony's power. It started with such a load on the gradient of 1 in 85, and carried it as far as was necessary at the rate of 5 miles an hour—the average pressure being 150 lbs. to the square inch. If the Welsh Pony could carry nearly 74 tons up such a gradient, and with this load also start on it, what could the Fairlie engine, the Little Wonder, do? It was supposed that it ought to pull double. If the Welsh Pony could, on a gradient of 1 in 85 manage 26 wagons full of slate, weighing with all else 74 tons, surely the Little Wonder could manage 52. Mr. Fairlie said he was quite prepared for this; he would stake the credit of his little engine on its power to carry such a load; and to show that he could be generous, he even added three wagons to the load; he thought his engine could manage 55 wagons. However, as the Welsh Pony had first of all been tried with an excessive load, it was but fair that the Little Wonder should be similarly tried. A train was prepared of 72 loaded wagons of slate, weighing 138 tons 17 cwt., with empty ones weighing 43 tons 10 cwt.; and when you add to this 56 passengers, weighing 4 tons, and the weight of the engine itself, 19½ tons, you have a total load of 206 tons. With this load the Little Wonder started from Portmadoc (steam pressure, 165 lbs.), and passing along the level embankment, went up the gradient 1 in 85 with perfect ease, and to the astonishment of all the visitors, who crowded round Mr. Fairlie and shook him heartily by the hand on such a triumph. His engine was warranted to do double the work of ordinary engines, and on trial it was found equal to treble the work. But then arose the question: The Little Wonder has pulled such a load up the gradient of 1 in 85, having had a good start on the level embankment; can it start with this load on the gradient itself? It was, perhaps, scarcely fair to make the trial, inasmuch as the day was wearing late, and the engine-driver had, through a misapprehension, let the fire run low. Still the trial was made, and with perfect success. There is this further, however, to be added, that whereas the shorter trains were standing when they started, or attempted to start, partly on a curve of 4½ chains radius, partly on a straight line, the train of the Little Wonder being much longer (it was 648 feet), stood partly on the curve of 4½ chains radius and partly on a reverse curve of a little wider sweep, which, of course, means an increased resistance, and might be resolved into an increase of gradient. Also let us add here, to complete the statement, what really happened four or five days afterwards, that whereas these experiments last described were intended to test the extreme power of the engines, other experiments followed to show what the Little Wonder could do, not merely in a short run, but in its ordinary daily work between Portmadoc and Festiniog. It took, for example, a train 407 ft. long, and loaded to 141½ tons, from Portmadoc to Festiniog, at a *maximum* speed of 15 miles an hour and an average one of 11¼. The usual practical load, however, of the Little Wonder upon the average gradient of 1 in 92 is from 90 to 100 tons (exclusive of engine), at from 12 to 15 miles an hour. On a level it is calculated that its power is equal to the carriage of 450 tons, at a speed of 14 miles an hour.

After the experiments on the Festiniog Railway the exploring party met together in council, under the presidency of the Duke of Sutherland, to hear Mr. Spooner read a paper on the wonderful little line of which he is the engineer, and to compare with each other their notes and impressions. Mr. Spooner gave ample information on every detail connected with his railway, which in the year ending June, 1869, had a mineral traffic of 118,132 tons, a goods traffic of 18,600 tons, and a passenger traffic of 97,000 persons, but no night traffic and no Sunday trains. His paper will, no doubt, be published, and those who may be interested in the subject will find in it all the statistics of which we have given the cream. We only state here that he wound up his remarks by saying that he does not recommend for light railways a gauge so narrow as 2 ft. The gauge he recommends is one of 2 ft. 6 in. The large amount of traffic which can be done with ease on lines of this limit is, he said, really surprising, and with the Fairlie engine it is quite equal to that which can be earned on a 4 ft. 8½ in. gauge. Hereupon the discussion became general, but we can refer to only a few of the opinions which were expressed. The Duke of Sutherland said he wished

he had known more of the Festiniog Railway six years ago. "I have expended," said his Grace, "about £200,000 in promoting and making railways in the north. Had these lines been constructed on the narrow gauge, and had they in consequence cost only two-thirds of the sum that has been expended on them, I should have obtained a direct return on this large sum which I have laid out for the benefit of my estates and of the people in those remote districts. As it is, I shall suffer considerable loss." Then Mr. Crawley insisted in a vigorous argument on the perfect sufficiency of the 2 ft. 6 in. gauge, if worked on the Fairlie system, for the heaviest traffic, and on the folly, if this were sufficient, of adding another inch to the gauge. The argument may be sound as regards heaviness of traffic, but as other considerations besides the weight to be carried have to be taken into account, as, for example, the comfort of passengers and the bulk of goods, say in a cotton country, it is natural that there should be some difference of opinion as to the precise narrow gauge which is best. It will be seen that Mr. Fowler and Mr. Fairlie have both recommended a 3 ft. gauge for India; and it is not at all unlikely that this gauge may ultimately be adopted in Russia. It is important that on this subject we should give the views of Captain Tyler, whose scientific attainments, and whose large experience as the Government Inspector of Railways, give a peculiar value to his opinions. He stated in substance at the meeting of commissioners what will be found more elaborated in his printed reports. Thus, in a paper which he read on April 11, 1865, before the Institute of Civil Engineers, he says:

"It is illegal at present to construct any passenger lines in Great Britain on a narrower gauge that 4 ft. 8½ in., or in Ireland than 5 ft. 3. in. The Act 9 and 10 Victoria, cap. 87, provides (section 1), 'that after the passing of this Act it shall not be lawful (except as hereinafter excepted [with reference to broad gauge railways]) to construct any railway for the conveyance of passengers on any gauge other than 4 ft. 8½ in. in Great Britain and 5 ft. 3 in. in Ireland;' and (section 6), 'that if any railways used for the conveyance of passengers shall be constructed or altered contrary to the provisions of this Act, the company authorized to construct the railway, or, in the case of any demise or lease of such railway, the company for the time being having the control of the works of such railway, shall forfeit £10 for every mile of such railway which shall be so unlawfully constructed or altered, during every day that the same continue so unlawfully constructed or altered;' and section 7 gives power to the Commissioners of Woods, etc., or to the Board of Trade, to abate or remove such railways, so constructed or altered, contrary to the provisions of the Act. It would therefore appear to be necessary, before constructing any railways for passengers on a less gauge than 4ft. 8½ in., or before attempting to open for passenger traffic any railways so constructed subsequently to the year 1846 (in which the above Act was passed), to endeavor to obtain, if not its repeal, at least a modification of its provisions. That Act was passed after the report of the Gauge Commissioners, when there was a strong feeling against break of gauge, and when there was no immediate prospect of a third and narrower gauge being extensively required. But there is now an increasing demand for branch railways of a minor class. Many coal and mineral lines are in use on a narrower gauge than 4 ft. 8½ in., and others are about to be constructed with ultimate views of passenger traffic. It would therefore be an advantage if some smaller gauge were recognized; for, however objectionable the existence of different gauges on important through lines of communication may be, it is quite otherwise with respect to the use of a narrower gauge for feeding branches, in districts where a similar gauge to those main lines would not be commercially practicable. Passengers change carriages under any system at the junctions of less important branches, and it is considerably cheaper to transfer heavy goods from one railway truck to another, than to cart them for several miles, perhaps over different roads. The Festiniog Railway, on which the original gauge has necessarily been maintained, in consequence not only of its own works, but also of those of the tramways and quarry inclines running into it, is an extreme example, outdone only by the little engine which does the work of the shops at Crewe on a gauge of 18 in.; and the cost of that railway, under

the peculiar circumstances of its original construction and subsequent alterations, cannot be taken as a guide for the future. A gauge somewhat wider than 2 ft. would probably be desirable on any line to be now constructed, and it would hardly be worth while to desert the gauge of 4 ft. 8½ in. in Great Britain for any gauge wider than 2 ft. 6 in. But whatever the exact gauge, whether 2 ft. 6 in. or 3 ft., or any other dimension that might be considered most suitable for lines of *minimum* traffic, there can be no question that a system of branch lines, costing two-thirds of the branches now ordinarily constructed, and worked and maintained at three-fourths of the expense of those branches, would be of decided benefit to Great Britain and Ireland, and would be most valuable in India and in the colonies ; in fact, wherever there are people to travel, produce to be transported, or resources to be developed, where it would not be commercially profitable to incur the expense, in the first instance, of a first-class railway."

On the same occasion he observed :—

"It is important to ascertain what would be a suitable gauge in those instances where the traffic is not likely to be large. Farmers are now using portable railways for transporting the produce of their fields, for bringing in their harvests, spreading manure, etc., and there seems no reason why districts which could not support a railway on the gauge of 4 ft. 8½ in. should be altogether deprived of the advantages of railway communication. The question of gauge is, in one sense, a question of speed. Speaking roughly, on a railway of 2 ft. gauge, with 2 ft. driving wheels, travelling might be made as safe at 20 miles per hour as on the the Great Western, with its 7 ft. gauge and 7 ft. driving wheels, at 70 miles per hour. I have travelled on parts of this little line at the rate of 30 miles per hour with every feeling of safety."

And again, in a report on the Festiniog Railway, addressed to the Board of Trade, he says :

"The adoption of the locomotive power upon this little line is very important, and has evidently been a very successful experiment. The cheapness with which such a line can be constructed, the quantity of work that can be economically performed upon it, and the safety with which the trains run over it, render it an example which will, undoubtedly, be followed sooner or later in this country, in India, and in the colonies, where it is desirable to form cheap lines for small traffic, or as a commencement in developing the resources of a new country."

It should be noted particularly that the inquiries instituted by the Russian and Indian Governments had reference not merely to the narrow gauge, but chiefly to the narrow gauge as made available by the Fairlie engine. Having examined into the working of the Fairlie engine on the narrow gauge, they proceeded southwards to see the working of another engine of the same type on the ordinary gauge, on the heavy gradients of the Mid-Wales Railway and the Brecon and Merthyr line. The Progress was, we believe, the first built of Mr. Fairlie's engines, and has several imperfections, being, for instance, deficient in heating surface. But taking it as the first rough exemplar of the system, its performance is certainly remarkable. It is a double engine, with a four-wheeled bogie under each end, the cylinders 15 in. in diameter, the stroke 22 in., and the wheels (4 ft. 6 in. in diameter) are coupled together in both bogie frames, so that all the wheels of the engine are driving wheels. The extreme wheel-base is 22 ft., but, what has alone to be considered in practice, the wheel-base of each bogie is only 5 ft. The heating surface is on the fire-box 92 ft., and in the tubes 1,901 ft., making a total of 1,992 ft. The total weight of the engine when fully equipped is 54 tons, including 1¾ tons of coals and 2,000 gal. of water. Also, the engine is fitted with the Chatellier steam break, which Mr. Fairlie was the first to introduce into this country, and its extreme length, from buffer to buffer, is 32 ft.

On the 14th of February the Progress left the Three Cocks Junction on the Mid-Wales Railway with 39 loaded wagons, 3 break vans and about 50 passengers and workmen, making a total weight of 526 tons, including the engine. It measured 732 ft. in length. The day was bitterly cold ; the hour was late ; Mr. Fairlie was anxious to hurry on ; and not waiting for the engine driver, who knew the road, he mounted the engine himself, and set off with his load. The result proved that though he may be a first-rate engineer he is not a good engine-driver. A man may

be a very good judge of horses and yet not a good jockey. An engine requires as careful management as a horse; and Mr. Fairlie, driving his own engine, made it go through its heaviest work; but when he came towards the end of the journey, and there was a trifle more to be done, it turned out that there was not steam enough to go on. The amateur engine-driver, unacquainted with the gradients, had turned on the water supply at the wrong place, and soon found himself deficient in steam. The same experiment had, therefore, to be repeated next day under the guidance of the regular engine-driver, when it was perfectly successful. The engine had to carry the load of 526 tons up several gradients and on reverse curves; the gradients were 1 in 75, 1 in 162, and 1 in 90. The total distance run was 14 miles, from the Three Cocks to Builth, which was done in about an hour, including stoppages. On the same day the engine was taken to some still more severe gradients on the Brecon and Merthyr Railway. She left Tall-y-llyn with a load of 180 tons at 2.51 P.M. After running for 3 miles, for the most part on a descending gradient of 1 in 40, she was brought to a stand at Talybout station, where her tanks were filled. She started from Talybout at 3.13 P.M., with a steam pressure of 140 lbs., and ascended a gradient of 1 in 35 for half a mile. She then mounted a gradient of 1 in 38 for 6⅝ miles, and passed the summit of that gradient at 4.16, with 120 lbs. of pressure. She passed through the tunnel—660 long, a rising gradient of 1 in 68—in 2¼ min., and was stopped at the Torpantan station at 4.18 P.M., the pressure continuing the same. This portion of the line, as well as the rising gradient of 1 in 38, contained curves of 12, 16, and 20 chains radius, and the train was so long that sometimes it had to pass over reverse curves. These are facts formally authenticated by official witnesses; but further authentic reports have reached London stating that since these trials the Progress has done work still more characteristic of a Hercules. Her performance showed clearly that as the Little Wonder makes a narrow gauge railway of 2 ft. do work hitherto deemed within the means only of a much broader gauge, so the Fairlie engine, on the standard gauge, enormously increases its working capacity, and that, too, without additional cost in proportion. There is but one opinion of the engineers of the lines examined—Mr. Broughton and Mr. Henshaw—as to the effect of the Fairlie engine upon the rails. It does far more work than any ordinary engine, and yet it is far less destructive to the permanent way

The invention of the double bogie, by which this result is brought about, is exceedingly simple—so simple that one wonders it was not thought of before. It is like the egg of Columbus—when once it was poised anybody could do the same thing. Now, when we see by the double bogie how to poise an engine so that it shall not oscillate, so that it can be indefinitely increased in size, and so that it shall not murder the rails in its violence, one is inclined to say, "We knew all this before; there is nothing novel here." There is nothing novel, the principle is obvious; but it was never before so applied as to have a practical result, and Mr. Fairlie has the credit of introducing into the construction of the locomotive one of those slight changes which lead right on to a prodigious development and almost to a revolution. We are on the brink of a new era in railways—the narrow gauge era—an era of renewed activity, when every village, almost every farmstead, may have its railway; and if such an era be now at hand it is mainly because the Fairlie engine, by its increased power, by its adaptation to the sharpest curves, by its economy on the rails, and by its freedom from oscillation, even upon rude roads, has rendered it possible. Bogie has arisen to the incantations of Mr. Fairlie, and promises to make the old railways work better than ever they did before, and to make new railways, of lighter, smaller, cheaper construction, that will vie in performance with any of the old.

THE Khedive is raising funds, on his personal account, for the purchase of sugar-refining machines, the construction of railways through his private property, and the greater extension of sugar-cane culture.

THREE hundred and fifty-seven passengers were injured in one collision on June 23rd, 1869, at New-cross station.

BORING MACHINES FOR MINES.

(See Frontispiece.)

The report on mining and the mechanical preparation of ores, by Mr. Henry F. Q. D'Aligny, United States Commissioner to the Paris Exposition of 1867, contains an interesting chapter by M. Alfred Geyler, a French engineer, upon the machines for drilling or perforating rock, which were exhibited there, from which we have made the following extracts :

M. Geyler begins by stating that the application of machinery, worked by steam or other power, to the drilling or perforation of rocks originated in the United States, several machines having been in operation there previous to 1853. They were of two kinds, viz. : those which prepared the rock for removal by the use of powder, and those which cut the rock so that it could be broken away without blasting.

All these machines were worked by steam, and their mode of action was sometimes that of the common drill of the miner, sometimes that of a cutting tool, but in neither of these machines had the idea of boring like an auger into wood, or a drill into iron been applied.

For some years this last-mentioned mode of boring had been employed in France with better results than those of other machines which had preceded them.

Perforators, or rock-drilling machines, can be divided, according to their mode of working, into two principal systems—percussion and rotary.

They may be worked either by hand or by some motive power, such as steam, compressed air, or water.

I. MACHINES FOR BORING BY PERCUSSION.

Only one machine of this kind, intended to be worked by hand was exhibited. It is called Trouillet's Excavator (cavateur Trouillet), and is employed for enlarging round holes from the bottom upwards. They can then receive much larger charges of powder. It consists essentially of a tube or pipe, of the same diameter as the hole, in which a stem or iron bar slides freely and gives motion to two steel cutters, which are hinged upon the bar. Whenever the bar is pushed down one end of each of the cutters is thrown outward and describes an arc of 90 deg., and when the bar is pulled up again they re-enter the pipe. If the whole machine is turned slowly the hole will gradually be enlarged, and as the height of the tool above the bottom of hole can be changed a cavity of any (not more than 0.30 metres) diameter and length can be formed. Cutters of different sizes are used successively, when a large cavity (0.30 inches in diameter) is to be formed.

BORING BY STEAM OR COMPRESSED AIR.

The boring machines of the second class, actuated by steam or compressed air, are divided into two systems, according to their mode of working.

The first includes the apparatus which serve to make the holes to be blasted with powder. The second comprises the machines intended to cut out the rock the size of the gallery by direct action, unaided by powder.

The best known power machines for boring blasting holes are—

1. Those of M. Sommeilier, employed at Mont Cenis.

2. The apparatus of Mr. Döring, of Prussia, employed for the last three years at the Vieille Montagne mine.

3. The borer of Mr. Bergstroem, of Sweden.

4. And lastly, the steam-borer of Mr. Herman Haupt, C. E., of Philadelphia, United States.

The first three are worked by compressed air, and consist essentially of three parts: a cylinder, by which the compressed air communicates a reciprocating motion to the drill, a mechanism by which the drill is turned, and a mechanism by which the working parts are made to advance as the hole becomes deeper. In the first two machines the latter mechanism is automatic ; in the third it is moved by the workman. In Mr. Haupt's machine steam is substituted for compressed air, and he has so arranged the apparatus that the drill always strikes the rock with the same force, and that the advance of the tool varies with the hardness of the rock. All the above apparatus act by percussion, and are, therefore, very liable to be broken and put out of order. The following account of the working of M. Sommeilier's

machine will give an idea of the amount of repairs which these machines require :

The apparatus placed before the breast of the gallery to be attacked carries 8 drills, which cover a section 4 metres wide by 3 metres high, equal to an area of 12 square metres. Eighty holes are bored, 6 of 6^m.09 and 74 of 0^m.04 diameter, and 0^m.90 deep. The daily work has varied evidently according to the hardness of the rock ; in March, 1863, it was 1^m.10 in 24 hours, in April 1^m.40, and in some parts of the strata even 2^m.50 ; but when the bank of quartz was met (which was 308 metres thick), the advance was hardly 0^m.50 per day.

During the month of March, 1863, it was shown that each explosion of 0^m.70 to 0^m.80 required 6 hours for boring the holes, and 4 hours for the miners carrying away the rubbish.

The staff employed for the boring of the holes during 24 hours was as follows :

	Men.
Two shifts	16
Miners	2
Laborers for taking away the debris	8
Superintendents	2
Total	28
Although we have not to take into account the motive engines, we ought to add that the compressors required	9
Total	37

If we examine the staff employed in repairing the tools, we remark that in 1863, for 8 machines working, there were 60 in the shop. At this time, when the work is carried on both from the French and the Italian sides, the number of engines working is 16, and of those in the workshops repairing 200.

In 1863, as we have stated, for repairing 8 perforators working in a coarse sandstone (*grès à gros grains*), the staff attached to the workshops was composed of—

	Men.
Blacksmiths repairing tools and parts of Machines	14
Fitters, turners, firemen, and boiler-makers,	10
Total	24

Thus 24 men were occupied daily in repairing 8 machines. At this time the number is much larger ; unfortunately it is almost impossible to obtain exact accounts of the cost of repairing. All that we know to be exact is that at this time the work has been offered to a company at 6,000 francs per running metre, giving them all the apparatus ; they to repair the tools and clear away the dirt. This was refused, although the price was equal to 500 francs per cubic metre.

The enormous shocks which the machine was subjected to obliged them to change the iron beds for Krupp steel ones ; the springs often broke, and the drills cannot advance 0^m.20 or 0^m.30 without requiring repairs.

Even admitting the possibility of constructing these machines strong enough to resist these causes of destruction, we still say the percussion system presents such disadvantages that render its adoption impossible ; for when, by the blows of the drill, pieces of rock are broken off, and instead of being thrown out they are still subjected to the blows and reduced to powder, this causes a loss of work. It is true that, to aid in clearing the holes at Mount Cenis, they injected water under a pressure of 5 atmospheres, but this was abandoned because the tool became clogged. At this time a jet of air at 5 atmospheres is forced in and drives the dust from the bottom of the hole. This dusty atmosphere must be injurious to the health of the workmen.

Besides, when the drill has penetrated the rock a short distance, it is no longer guided and supported, and its vibrations are so considerable that they can only be compared to those of the axles of railway wheels. These vibrations evidently prevent the making of a uniformly circular hole, and leave ridges in the hole, which prevents the use of cartridges, which are much better than to ram in powder.

We ought, lastly, to add that the boring of the holes is but a part of the work to be done ; there still remains the work of of clearing out and removing the dirt and debris. It is necessary that the boring machine should be solid enough to require little repair, so that the cost for tools shall not be altogether out of proportion to the work done.

An account of some of the above machines will be found in "Spon's Dictionary of Engineering," in the article, "Boring and Blasting."

BEAUMONT'S AND LOCOCK'S DRILLING ENGINE.

This machine is worked by compressed air ; its object is to pierce a gallery 2

metres in diameter entirely by the machine, aided by powder, for disengaging the core of rock, which is left inside of the annular trench cut by the drills. This machine is composed of a circular cast-iron plate, which carries on its circumference 50 drills, and at its centre a single drill. The diameter of the plate is the same as that of the gallery to be driven. It is fixed on a hollow iron shaft about $\frac{2}{3}$ of its length, being a piston moving in a cylinder, by means of which a reciprocating motion is given to the drills, while at the same time the disc is turned. We will not dwell upon the description of the machine, which has seen the day light, but which we think will never see the end of a gallery in a mine or tunnel. It weighs more than 10 tons.

II. BORING BY ROTATION.

We have before pointed out the imperfections inherent and inevitable in the system of boring by percussion, and however ingenious the combination given to the apparatus, we are convinced they are destined to disappear and to give way to the system of rotating borers, which will now be described.

The borers by rotation are divided, like those by percussion, into two classes; the first comprises those worked by hand, the second those which require water, steam, or compressed air as the motive power.

Among the first we remark the borer of Lisbet and Jacquet, Mr. Leschot's borer, constructed by Mr. Pitet, and lastly Mr. Trouillet's rotating excavator.

BORER OF LISBET AND JACQUET.

The tool of this borer is formed of a blade of corrugated steel $0^m.007$ thick and $0^m.035$ wide, twisted like an auger bit, so that it draws from the hole the debris of the rock detached by the cutting end, which has two edges, making a very obtuse angle, like a drill for perforating metals. This tool offers a certain peculiarity; the drill, instead of advancing according to the hardness of the rock, works in the manner of a screw turning in a fixed nut, and is expected to penetrate at a certain rate, irrespective of the hardness of the material being bored. By this arrangement, if the rock is too hard to be overcome by the motive power used, the drill either stops or breaks. The screw of the drill-carrier has 4 threads per centimetre, so that the rate of progression is $0^m.01$ for 4 turns.

The frame of the drill-carrier is ingeniously arranged, to enable it to be moved rapidly and to make holes in all directions.

The support or frame for this drill consists of an upright, or standard, to be sustained in the drift, or gallery, by steel points at each end, one of which can be forced against the roof by a screw, while the other rests upon the floor. The body of this standard is double, and so made that a sliding-drill support can be raised or lowered in it, and be sustained at any desired height by means of pins. Motion is given to the drill by means of a winch and ratchet working in the usual way.

From experiments made with this machine it was found—

1. That the erection and working of the apparatus require considerable skill and judgment.

2. That in granular and homogeneous stone the borer acts well.

3. That in hard sandstone and quartz it has no action on the rock, and the tool wears up quickly; also that it works irregularly in rocks that contain masses of quartz.

4. And lastly, that in wet rocks the work is difficult, and the rate scarcely appreciable.

LESCHOT'S DRILL.

The imperfections that Mr. Leschot, civil engineer and pupil of the Central School, had recognized in the use of iron or steel in the boring of hard rocks or of metals, the drills softening rapidly, and often producing only an advance of $0^m.07$ to $0^m.10$ per hour, gave him the happy idea of applying a rotating tool acting in the manner of an annular cutter, and in which steel teeth should be replaced by diamonds. To accomplish this, he sets into a tubular washer or ring, about $0^m.005$ or $0^m.006$ thick, black diamonds projecting $0^m.0005$ at the most, some from within, some from without, and some in front.

The opposite end carries an adjustment like a bayonet joint, which admits of this crown being adjusted upon a tube as a bayonet is placed upon a gun-barrel. He imparts to this ring so arranged a rotary movement, and at the same time presses

it with considerable force against the stone to be bored.

The first experiments that were made with this apparatus, which was mounted on a frame something like that of the Lisbet borer, led to the belief that this new system of boring the rock would be a complete success. In a granite of medium hardness, two men could bore $0^m.025$ per hour; the cylindrical core left in the centre was $0^m.031$ in diameter, and the annular groove $0^m.043$ in diameter; consequently the part pulverized was equal to a cylinder $0^m.012$ thick.

Unfortunately experience has not confirmed the happy debut of this apparatus; not because the employment of the ring was bad, but solely on account of the mode of advancing the drill, which depends on the velocity of the rotation of the cutting ring. The principle of this arrangement for advancement is evidently defective, for it is impossible to have a constant regular rate of advance in rocks which, by their nature, are constantly varying in hardness. In the soft parts of the rock, the advance of the tool not having been quick enough, it did not produce its maximum amount of work; while in the hard rocks, quartz for instance, the advance was too rapid, and the diamonds were either displaced or reduced to powder.

TROUILLET'S ROTATING EXCAVATOR.

This, like the percussion apparatus by the same inventor, is intended to enlarge the lower portions of ordinary drill holes so as to make chambers for the reception of powder. It is similarly constructed, except that the work is performed by the rotation of steel cutters, attached to a central stem or shaft, to which motion is given by two cranks and gearing. The weight of the apparatus is 60 kilogrammes, and its price is 450 francs.

DE LA ROCHE-TOLLAY AND PERRET'S BORING APPARATUS.

The complete apparatus of Messrs. De La Roche-Tollay and Perret is composed of four distinct parts:

1. The carriage which bears the borer.
2. The motive power.
3. The borer.
4. The tool.

Carriage or Support.—This borer is intended to be arranged differently, according to the conditions under which it is to work. When it is intended to bore but one hole, a single tool is used; when the front of a gallery or a tunnel is to be pierced in several points simultaneously, several boring machines will be indispensable. Consequently, in each particular case, the carriage or tool-bearer should be modified according to the local requirements. We do not, therefore, enter into the relative details of this part of the machine; we will merely state that Messrs. Huet and Geyler, engineers, have studied the different arrangements of the tool-carrier, and they have succeeded in rendering the working of the borer or borers easy and quick, in permitting them to assume any required direction on the carriage which bears them, and in giving an arrangement by which the carriage or support can be attached easily to the roof or wall of the gallery as well as upon the sides, and removed away rapidly to allow the powder to be fired and to carry away the debris. This arrangement is shown in the frontispiece.

Motive power.—This hydraulic motor has been contrived by Mr. Perret, civil engineer at Bordeaux; it is composed of a horizontal cylinder bolted on the frame of the borer.

This cylinder carries at its upper part a nozzle, to which is adapted a pipe in india-rubber, intended to conduct the water to the engine.

In this cylinder a bronze tube is fitted, which we call the regulator. This is bored and turned with the greatest nicety, and is pierced with port-holes at the end. It receives a reciprocating motion from an eccentric, made of one piece, upon the axle of the engine.

Two boxes furnished with segments in bronze, pressed by steel springs, maintain the regulator rigorously in the axis of the inner cylinder, which serves to envelop it. These segments have the effect of stopping the passage of the water round the regulator during its longitudinal movement.

In the interior of the regulator there is a movable piston $0^m.055$ in diameter, furnished with capped leathers, upon the two faces of which the water alternately exerts its pressure. The length of stroke is $0^m.120$. A connecting rod changes it into a continuous rotary motion in connection with a cranked shaft provided with two fly-wheels acting as regulators.

In order to ascertain the power of this new motive engine, we took 300 litres of water, the pressure of which varied from 3 to 9½ atmospheres, and we proved by means of Prony's break, in seven experiments that we made, that the practical result of the engine was 47 to 57 per cent. of the theoretical effect. This machine represented under the maximum pressure of 9½ atmospheres, theoretically 3.82 horse-power, and practically 2.11 horse-power.

We shall presently show that the regular speed of this little machine ought to be from 200 to 250 revolutions per minute. This is represented by 140 litres of water per minute, and a practical effect of 1.70 horse-power, the water being at a pressure of 8 atmospheres.

It will at once be seen what an important service this motive power will render when there is a sufficient supply of water. For example, at Mont Cenis (Bardonnèche) the torrent of Melzet has a fall of 45 metres ; admitting that it is 35 metres only, to give allowance for loss, it follows that each machine on Mr. Perret's principle would expend 320 litres per minute for one boring tool ; thus, for the eight machines which are at work on the face of the rock, 2,560 litres, or 44 litres per second, would be required. The quantity of water at present used for working the compressors is 600 litres. It will be claimed as an advantage that the compressed air serves to aerate the gallery ; this is true, but we find in the official returns that it requires for working the 8 borers 6,250 cubic metres of air for 24 hours, while 2,160 cubic metres is sufficient to renew the air vitiated by the 15 men at work in the head of the gallery ; it is also true, that they have sought to establish the fact that the balance, 4,000 cubic metres, was necessary to expel the noxious gases produced by the explosion of the powder ; but practice has proved that much more powerful and artificial means were required for this purpose. It would appear to us more rational to employ a part of the 566 litres remaining to work a Perret machine to drive an air ventilator. We ought also to add that the erection of the compressors and their buildings at Bardonnèche has cost 1,250,000 francs, and three-fourths of this expense would have been saved by the employment of Mr. Perret's machine.

The boring machine of Mr. Perret is composed of a six-sided cast steel shaft, $1^m.45$ long, bored throughout its entire length with a hole $0^m.016$ diameter. This axle receives the boring tools at one of its extremities.

The other extremity of the axle carries a bronze piston $0^m.12$ diameter, upon which the requisite pressure is exerted for maintaining and pressing the drill against the face of the rock. This pressure is varied according to the hardness or the nature of the rock. A pressure of eight atmospheres is abundantly sufficient for boring hard rocks, such as the quartz of Mont Cenis and the granite of the Pyrenees. The pressure should be diminished for calcareous rocks to five or six atmospheres at most. Thus, with a pressure of eight atmospheres, the effort on the drill is equal to 784 kilogrammes.

The water employed to act against the piston of the propeller is conveyed by an india-rubber hose, the extremity of which is provided with a cock to regulate the pressure as may be required.

To remove the perforating tube after a hole has been cut, the passage of the water to the cylinder is intercepted by a cock, and the flow is directed against the front face of the piston, admitting, at the same time, of the cylinder being emptied. In this manner the tube can be replaced with the greatest facility.

The perforating shaft is fitted on the inside with a bronze frame, accurately bored to a depth of $1^m.14$, for the propelling piston to work in. Holes from $0^m.90$ to $1^m.00$ deep, and from $0^m.035$ to $0^m.06$, can be bored by this machine.

The tool-bearing shaft traverses an iron socket held between two bearings arranged in front of the framing. The socket is provided with a bevel pinion, to which motion is imparted through the medium of an inclined shaft by a brass wheel keyed on the main shaft.

From the foregoing it will be seen that in order to apply this borer to the Mont Cenis works, it should have a piston $0^m.16$ diameter, since the pressure of the water there is only 3½ atmospheres.

The perforating tool made use of until recently by Messrs. De La Roche-Tollay and Perret is the Leschot ring previously described, but there are still some points to be explained to complete the information relating to this kind of drill.

It is understood that after the ring has been attached to the six-sided perforating shaft, if it is rotated at a speed of about 200 revolutions per minute, by the effect of pressure exerted on the propeller piston, the black diamonds brought in contact with a softer substance will cut and wear it to an extent which will depend on the pressure on the piston and the hardness of the rock. By continuing this labor the groove can be made to a great depth, and the cylindrical core which remains attached to the rock enters the hole through the axis of the tool-carrier. When the operation is terminated the core is taken out in the shape of quite a regular cylinder, which only breaks when the rock is of a brittle nature, or has been previously cracked. It is evident that the use of this cutting ring saves considerable power, since a part of the rock is not pulverized. In the example which we have given in describing the Leschot perforator, the effort was only 61.441 tons per hour, while it would have been 204.5 tons if the entire matter had been pulverized. The ring employed by Messrs. De La Roche-Tollay and Perret is only $0^m.035$ outside diameter, and the core worked was $0^m.014$ in diameter.

Cost of the tools.—We will now reply to an objection which has been raised as to the price of the tool. It is true that when the ring was first used a difficulty existed in the selection of the diamonds, which, from the nature of their cleavage, would be the most serviceable. The setting was not always performed as solidly as could be desired; but these difficulties have disappeared. We have examined two rings which were worked for seven months at the Exposition, and which have perfectly resisted. We believe that we can affirm that in a hard stone like granite, a ring properly worked will cut holes to an aggregate depth of 150 metres. A ring for boring holes, $0^m.036$ diameter, costs about 150 francs, but as the black and opaque diamonds used in its construction are ordinarily employed in the shape of dust for polishing transparent diamonds, and as their wear during the act of perforation is very slight, they can be extracted from the socket in which they are set, and be returned to the trade with a depreciation proportionate only to the diminution of weight. The diamonds extracted from a worn-out ring generally fetch from 70 to 80 francs—that is to say, about one-half of their first cost.

The following are the results of the experiments made during the Exposition. The pressure on the propelling piston was eight atmospheres, and the speed varied from 250 to 280 revolutions per minute.

Advance per minute: In the pure Mont Cenis quartz, $0^m.054$; in the Morvan porphyries, $0^m.042$; in granite, $0^m.050$; in ———, $0^m.018$; in very hard calcareous dolomite, $0^m.080$.

The holes were perfectly regular, and, being so, were well adapted to the use of powder cartridges, which are much less dangerous than the ordinary use of powder.

As the pressure of the water injected into the hole through the hollow is the same as that acting on the piston, the powdered debris are washed away with the greatest facility.

The hydraulic engine and the perforator have worked every day, during four hours, in a period of seven months, without necessitating any serious repairs. The most important were, repairing the piston-head bearings of the water engine and verifying the state of the segments belonging to the engine.

The weight of the entire apparatus is equal to that of those used at Mont Cenis, viz., about 200 kilos.; its price, including the engine, but without the support, is 2,500 francs.

We cannot refrain from making a comparison between this perforator and the one employed at Mont Cenis. Its solidity, proved by 7 months' work, gives the assurance that 20 to 22 of these perforators would be sufficient for the heads of both galleries, including duplicates, instead of at least 220 actually existing. Mr. Sommeilier's perforators cost the same as those of Messrs. De La Roche-Tollay and Perret. The staff would be 4 times less, for one man can easily attend 4 perforators; thus 4 men instead of 16 would suffice for 24 hours at the two galleries.

The repairs to the rings require neither forges, lathes, nor workshops; and we are convinced that a workman to each gallery would be sufficient for the repairs of all the perforators. We have stated that the rate of advance in the Mont Cenis quartz was $0^m.054$ per minute, under a pressure of 874 kilos. on the propelling piston;

therefore a hole 0m.90 could have been driven in 16 minutes, say 20, and as each perforator should make 10 holes, say 3½ hours, even doubling this time for preparing the work, it will be seen that 5 stopes can be done in 2 days, including the time for blasting and clearing away the debris, which is equivalent to an advance of 2m.25 per diem, instead of barely 0m.50, the actual rate of advance.

The apparatus of Messrs. De La Roche-Tollay and Perret is not subjected to any shock; the pressure is exerted on the rock irrespective of the speed of the tool, and such pressure can be regulated as may be desired; and when water power is obtainable, which is generally the case in mines and tunnels, the motive power actually costs nothing.

Mr. Perret's machine can also be worked by compressed air, and for this it would be sufficient to add a hydraulic accumulator to the perforator carriage. Such an accumulator would be but small, since the volume of water required for advancing the piston 1 metre is 9½ litres, it would be sufficient to add 2 or 3 litres per hole, 1 metre deep, for washing out the holes.

ON SOME MECHANICAL EFFECTS OF MAGNETIZATION.

From "The Engineer."

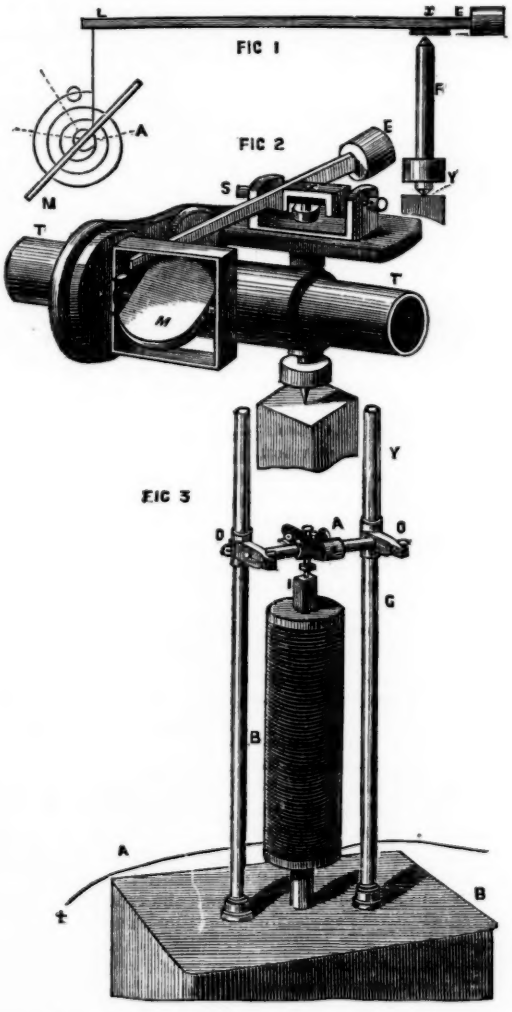
We are indebted to the courtesy of Prof. Tyndall for the following account of a piece of apparatus used by him in his researches in magnetism, which cannot but interest our readers. We are thus able to anticipate by a short period the publication of his new work, in which, among other essays, letters, and reviews, this apparatus and its use will be explained:—

"Wishing in 1855 to make the comparison of magnetic and diamagnetic phenomena as thorough as possible, I sought to determine whether the act of magnetization produces any change of dimensions in the case of bismuth, as it is known to do in the case of iron. The action, if any, was sure to be infinitesimal, and I therefore cast about for a means of magnifying it. The idea which appeared most promising was to augment in the first instance by a lever the small amount of change expected, and to employ the augmented effect to turn the axis of a rotating mirror. By making the axis small enough it was plain that an infinitesimal amount of rectilinear motion might be caused to produce a considerable amount of angular motion. This I proposed to observe by a telescope and scale after the method of Gauss. I consulted Mr. Becker, and thanks to his great intelligence and refined mechanical skill, I became the possessor of the apparatus now to be described.

"A B (Fig. 3) is the upper surface of a massive block of Portland stone. It is 21 in. wide, 13 in. deep, and 29 in. high. In it are firmly fixed two cylindrical brass pillars C, C, 1 in. in diameter and 35 in. in height. Over the pillars pass the two clamps O, O, and from the one to the other passes a cylindrical cross bar, 11 in. long and ¾ in. wide. This cross bar is capable of two motions—the first up and down the two pillars C, C, parallel to itself; the second being a motion round its own axis. To this cross piece is attached the magnifying apparatus A.

"The bar to be examined is set upright between the two pillars, being fixed firmly to a leaded screw embedded in the Portland stone. It is surrounded by an electro-magnetic helix B. On the top of the bar I rests one end of a small cylindrical brass rod, with pointed steel ends. This rod fits accurately into a brass collar, moving up and down in it with the least possible friction. The other point of the rod presses against a plate of agate very close to a pivot round which the plate can turn. The agate plate is attached to a brass lever 2.1 in. long, whose fulcrum is the pivot just mentioned. Any motion of the point against which the rod presses is magnified about 50 times at the end of the lever. From this end passes a piece of fine steel fibre round the axis of a rotating mirror, which turns as the end of the lever moves. The mirror rotates with its axis. For accurate experiments an illuminated vertical scale is placed at a distance of about 12 ft. from the mirror, which is observed through a telescope placed beside the scale. A naked section of the magnifying apparatus is given in Fig. 1. The magnifying apparatus

is shown in detail in Fig. 2, where M is the mirror; S and S′ are two centre-screws, whose points constitute the pivot round which the lever turns; E is a small counterweight; T, T is the cross-piece to which the magnifying apparatus is attached; I is the bar to be magnetized, F the brass rod with the pointed steel ends, divested of its collar, and pressing against the plate of agate near the pivot *x*.



From the end L of the lever the steel fibre passes round the axis *a* of the mirror M. When the bar I changes its length, the motion at L turns the mirror; and when I resumes its primitive length the mirror is brought back to its first position by the spiral hair-spring shown in the figure.

"In a lecture, of which the following is an abstract, the instrument just described was employed to show the elongation of a bar of iron by magnetism. It is the

instrument referred to in 'Heat as a Mode of Motion,' 3rd edition, p. 85. Merely breathing against an iron bar produces a visible expansion. By squirting warm water from a syringe-bottle against the bar, and by employing ether or alcohol in the same way for cooling, the luminous beam which forms the index may, in a few seconds, be caused to pass through a distance of 20 or 30 ft.

"ON A MAGNETIC EXPERIMENT.*

"Some years ago I devised an apparatus to enable me to investigate certain mechanical effects which accompany the act of magnetization. I wished to apply this apparatus to diamagnetic bodies as well as paramagnetic ones—to bodies such as bismuth, as well as to bodies such as iron. I intend this evening to show you the action of this instrument, and to lay before you some explanation of experiments of which mine are merely confirmatory.

"Let us pass quickly in review the excitation of this wonderful power of magnetism. Over the poles of this strong horse-shoe Logeman magnet I pass a bent bar of steel, whose arms are the same distance apart as those of the magnet. The steel bar suddenly obtains the power of attracting this iron keeper, and holding it fast. On reversing the stroke of the steel bar its virtue disappears; it is no longer competent to attract the keeper. I continue the stroke of the steel bar in the last direction, and now it is again competent to attract the iron; thus at will we can magnetize and demagnetize this bent piece of steel.

"At the other side of the table you observe another mass of metal, bent like the Logeman magnet, but not like it, naked. This mass, moreover, is not steel, but iron, and it is surrounded by coils of copper wire. At the present moment this huge bent bar is so inert as to be incapable of carrying a single grain of iron. I now send an electric current through the coils that surround it, and its power far transcends that of the steel magnet on the other side. It can carry fifty times the weight. It holds a 56 lbs. weight attached to each of its poles, and it empties this large tray of iron nails when they are brought sufficiently near it. On interrupting the current, the power vanishes, and the nails fall.

"Now the magnetized iron cannot be in all respects the same as the unmagnetized iron. Some change must take place among the molecules of the iron bar at the moment of magnetization. And one curious action which accompanies the act of magnetization I will now try to make sensible to you. Other men have labored, and we are here entering into their labors. The effect I wish to make manifest was discovered by Mr. Joule, and was subsequently examined by MM. De la Rive, Wertheim, Marian, Matteucci, and Wartmann. It is this. At the moment when the current passes through the coil surrounding the electro-magnet, a clink is heard emanating from the body of the iron, and at the moment the current ceases a clink is also heard. In fact, the acts of magnetization and demagnetization so stir the particles of the magnetized body that they, in their turn, can stir the air and send sonorous impulses to our auditory nerves.*

"The sounds occur at the moment of magnetization, and at the moment when magnetization ceases; hence, if a means be devised of making and breaking, in quick succession, the circuit through which the current flows, we shall obtain an equally quick succession of sounds. I do this by means of a contact-breaker which belongs to a Ruhmkorff's induction coil. A thin bar of iron stretches from one of the bridges of this monochord to the other. This bar is placed in a glass tube, which is surrounded by copper wire. The contact-breaker is placed in a distant room, so that you cannot hear its noise. The current is now active, and every individual in this large assembly hears something between a dry crackle and a musical sound issuing from the bar in consequence of its successive magnetization and demagnetization.

"Hitherto we have occupied ourselves with the iron which has been acted upon by the current. Let us now devote a moment's time to the examination of the current itself. This naked copper wire is quite unable to attract these iron filings; but I send a voltaic current through it; and now it grapples with the filings, and holds them round it in a thick envelope. I interrupt the current and the filings fall. Here, also, is a compact coil of

* Proceedings of Royal Institution, vol. iv., p. 317.

* The sound, I find, was first noticed by Mr. Page.—J. T., 16th June.

copper wire, which is overspun with cotton to prevent contact between the convolutions. On sending a current through the coil, a power of attraction is instantly developed, which enables it to empty this plate of iron nails.

"Thus we have magnetic action exhibited by a body which does not contain a particle of the so-called magnetic metals. The copper wire is made magnetic by the electric current. Indeed, by means of a copper wire through which a current flows, we may obtain all the effects of magnetism. A long coil is suspended before you, so as to be capable of free motion in a horizontal direction; it can move all round in a circle like an ordinary magnetic needle. At its ends I have placed two spirals of platinum wire, which the current will raise to brilliant incandescence. They are glowing now, and the suspended coil behaves in all respects like a magnetic needle. Its two ends show opposite polarities; it can be attracted and repelled by a magnet, or by a current flowing through another coil; and it is so sensitive that the action of the earth itself is capable of setting it north and south.

"There is an irresistible tendency to unification in the human mind; and, in accordance with our mental constitution, we desire to reduce phenomena which are so much alike to a common cause. Hence the conception of the celebrated Ampère that a magnet is simply an assemblage of electric currents. Round the atoms of a magnet Ampère supposed minute currents to circulate incessantly in parallel planes; round the atoms of common iron he also supposed them to circulate, but in all directions—thus neutralizing each other. The act of magnetization he supposed to consist in the rendering of the molecular currents parallel to a common plane, as they are supposed to be in a permanent magnet.

"This is the celebrated theory of molecular currents propounded by Ampère. You observe it consists in the application of conceptions obtained from sensible masses of matter to insensible or atomic masses. Let us follow out this conception to what would appear its legitimate consequences. I have said that we obtain both attractions and repulsions from electric currents; all these effects are deduced from one law, which is, that electric currents flowing in the same direction attract each other, while, when they flow in opposite directions, they repel each other. Let me illustrate this law rapidly. Before you are two flat coils facing each other, and about 8 in. apart. I send a current through both in the same direction; the coils instantly clash and cling together in virtue of their mutual attraction. I now reverse the current through one of them; and they fly a yard asunder in virtue of their mutual repulsion. And now one of them twists its suspending wire so as to turn its opposite face to the other coil; the currents are now again in the same direction, and the coils clash and cling as in the first instance. Imagine, then, our molecular currents flowing round the atoms of this iron bar in planes perpendicular to the length of the bar. From the law just enunciated we should infer the mutual attraction of those currents; and from this attraction we should be disposed to infer the shortening of the bar at the moment of magnetization. Here, for example is a coil of copper wire suspended vertically; the end of the coil dips into this little basin of mercury. From a small voltaic battery behind, I send a current through the coil, and, because it passes in the same direction through all its convolutions, they attract each other. The coil is thereby shortened; its end quits the mercury with a spark; the current ceases; the wire falls by its own gravity; the current again passes, and the wire shortens as before. Thus, you have this quick succession of brilliant* sparks produced by the shortening of the wire and the interruption of the current as it quits the mercury.

"Is it a fact, then, that an iron bar is shortened by the act of magnetization? It is not. And here, as before, we enter into the labors of other men.

"Mr. Joule was the first to prove that the bar is lengthened. Mr. Joule rendered this lengthening visible by means of a system of levers and a microscope, through which a single observer saw the action. The experiment has never, I believe, been made before a public audience; but the instrument referred to at the commencement of this lecture will, I

* Rendered brilliant by the introduction of a coil of wire and a core of soft iron into the circuit.

think, enable me to render this effect of magnetization visible to everybody present.

"Before you is an upright iron bar, 2 ft. long, firmly screwed into a solid block of wood.* Sliding on two upright brass pillars is a portion of the instrument which you see above the iron bar. The essential parts of this portion of the apparatus are, first, a vertical rod of brass, which moves freely and accurately in a long brass collar. The lower end of the brass rod rests upon the upper flat surface of the iron bar. To the top of the brass rod is attached a point of steel; and this point now presses against a plate of agate, near a pivot which forms the fulcrum of a lever. The distant end of the lever is connected, by a very fine wire, with an axis, on which is fixed a small circular mirror. If the steel point be pushed up against the agate plate, the end of the lever is raised; the axis is thereby caused to turn, and the mirror rotates. I now cast a beam from an electric lamp upon this mirror; it is reflected in a luminous sheaf, 15 or 16 ft. long, and it strikes our screen, there forming a circular patch of brilliant light. This beam is to be our index; it will move as the mirror moves, only with twice its angular velocity; and the motion of the patch of light will inform us of the lengthening and shortening of the iron bar.

"I employ two batteries, one to ignite the lamp, and the other to magnetize the iron bar. At present no current is passing. Let us make the circuit; the bright image on the screen is suddenly displaced. It moves through the distance of a foot. I break the circuit; the bar instantly shrinks to its normal length, and the image returns to its first position. However often you make the experiment the result is the same. When the bar is magnetized the image always descends, which declares the lengthening of the bar. When the current is interrupted the image immediately rises. This is the first time that this action of magnetism has been seen by a public audience.

"The same apparatus has been employed in the examination of bismuth bars; and, though considerable power has been applied, I have hitherto failed to produce any sensible effect. It was at least conceivable that complementary effects might be here exhibited, and a new antithesis thus established between magnetism and diamagnetism.

"And now for the explanation of this action. I place this large flat magnet upon the table; over it a paper screen; and on the screen I shake iron filings. You know the beautiful lines in which those filings arrange themselves—lines which have become classical from the use made of them in this institution; for they have been guiding-threads for Faraday's intelligence while exploring the most profound and intricate phenomena of magnetism. These lines indicate the direction in which a small magnetic needle sets itself when placed on any of them. The needle will always be a tangent to the magnetic curve. A little rod of iron, freely suspended, behaves exactly like the needle, and sets its longest dimension in the direction of the magnetic curve. In fact, the particles of iron filings themselves are virtually so many little rods of iron, which, when they are released from the friction of the screen by tapping, set their longest dimensions along the lines of force. Now, in this bar magnet the lines of force run along the magnet itself, and, were its particles capable of free motion, they also would set their longest dimensions parallel to the lines of force, that is to say, parallel to the length of the magnet. This, then, is the explanation given by M. de la Rive of the lengthening of the bar. The bar is composed of irregular crystalline granules; and when magnetized, these granules tend to set their longest dimensions parallel to the axis of the bar. They succeed partially, and produce a microscopic lengthening of the bar, which, suitably magnified, has been rendered visible to you. The explanation seems to me as satisfactory as it is acute.

"Let me now endeavor to render these beautiful magnetic curves visible to you all. From an electric lamp turned on its back a vertical cylinder of light issues. Over the aperture of the lamp are placed two small bar magnets, enclosed between two plates of glass. The vertical beam is received upon a looking-glass which reflects it on to the screen. In the path of this reflected beam is placed a lens,

* The wood was employed merely for lecture-room purposes; for accurate observations the iron bar was always fixed upon the block of Portland stone.—J. T., 1870.

which projects upon the screen a magnified image of the two small magnets. And now I sprinkle fine iron sand on the plate of glass, and you see how it arranges itself under the operation of the magnets. A most beautiful display of the magnetic curves is now before you. And you observe, when I tap the glass, how the particles attach themselves by their ends, and how curves close in upon each other. In the solid iron bar they also try to attach themselves thus, and close thus up; the consequence is, that the longitudinal expansion is exactly counterbalanced by the transverse contraction, so that the volume of the bar remains unchanged.

"But can we not bring a body with movable particles within an electro-magnetic coil? We can; and I will now, in conclusion, show you an experiment devised by Mr. Grove, which bears directly upon this question, but the sight of which, I believe, has hitherto been confined to Mr. Grove himself. At all events, I am not aware of its ever having been made before a large audience. This cylinder with glass ends contains a muddy liquid, the muddiness being produced by the magnetic oxide of iron which is suspended mechanically in water. Round the glass cylinder are coiled 5 or 6 layers of covered copper wire; and here is a battery from which a current can be sent through the coil. First of all I place the glass cylinder in the path of the beam from our electric lamp, and, by means of a lens, cast a magnified image of the end of the cylinder on the screen. That image at present possesses but feeble illumination. The light is almost extinguished by the suspended particles of magnetic oxide. But, if what has been stated regarding the lines of force through the bar of magnetized iron be correct, the particles of the oxide will suddenly set their longest dimensions parallel to the axis of the cylinder, and also in part set themselves end to end when the current is sent round them. More light will be thus enabled to pass; and now you observe the effect. The moment the circuit is established the disc upon the screen becomes luminous. When the current is interrupted, gloom supervenes; I re-establish it, and we have a luminous disc once more.

"The apparatus before you, was as stated, really invented to examine whether any mechanical effect of this kind could be detected in diamagnetic bodies, but hitherto without result. And this leads me to remark on the large ratio which the failures of an original inquirer bear to his successes. The public see the success; the failure is known to the inquirer alone. The encouragement of his fellowmen, it is true, often cheers the investigator and strengthens his heart; but his main trials occur when there is no one near to cheer him, and when, if he works aright, he must work for duty and not for reputation. And this is the spirit in which work has been executed in this institution, by a man who has, throughout his life, turned a deaf ear to such allurements as this age places within the reach of scientific renown; and it behooves every friend of this institution to join in the wish that that man's spirit may continue to live within its walls, and that those who come after him may not shrink from his self-denial should they ever hope to merit a portion of his fame.

"Biot found it impossible to work at his experiments on sound during the day in Paris; he was obliged to wait for the the stillness of the night. I found it almost equally difficult to make accurate experiments, requiring the telescope and scale, with the instrument just described, in London. Take a single experiment in illustration. The mirror was fixed so as to cause the cross-hair of the telescope to cut the number 727 on the scale; a cab passed while I was observing; the mirror quivered, obliterating the distinctness of the figure, and the scale slid apparently through the field of view and became stationary at 694. I went upstairs for a book; a cab passed, and on my return I found the cross-hair at 686. A heavy wagon then passed, and shook the scale down to 420. Several carriages passed subsequently; the figures on the scale were afterwards 350. In fact, so sensitive is the instrument, that long before the sound of a cab is heard its approach is heralded by the quivering of the figures on the scale.

"Various alterations which were suggested by the experiments were carried out by Mr. Becker, and the longer I worked with it the more mastery I obtained over it; but I did not work with it sufficiently long to perfect its arrange-

ments. Some of the results, however, may be stated here.

"At the beginning of a series of experiments the scale was properly fixed, and the pressure of the pointed vertical rod F, Fig. 1, on the end of the iron bar, I, so regulated as to give the mirror a convenient position; then, before the bar was magnetized, the figure cut by the cross-hair of the telescope was read off. The circuit was then established, and a new number, depending on the altered length of the bar by its magnetization, started into view. Then the circuit was interrupted, and the return of the mirror towards its primitive position was observed. The mirror, as stated, was drawn back to its first position by the spiral hair-spring shown in Fig. 1. Here are some of the results: Bar unmagnetized, figure of scale, 577; bar magnetized, 470; bar unmagnetized, 517.

"Here the magnetization of the bar produced an elongation expressed by 107 divisions of the scale, while the interruption of the circuit produced only a shrinking of 47 divisions. There was a tendency on the part of the bar, or of the mirror, to persist in the condition superinduced by the magnetism. The passing of a cab in this instance caused the scale to move from 517 to 534—that is, it made the shrinking 64 instead of 47. Tapping the bar produced the same effect.

"The bar employed here was a wrought-iron square one 1.2 in. on a side and 2 ft. long.

"The following tables will sufficiently illustrate the performance of the instrument in its present condition. In each case are given the figures observed before closing, after closing, and after interrupting the circuit. Attached to each table, also, are the lengthening produced by magnetizing and the shortening consequent on the interruption of the circuit:

Circuit.	Scale. 10 cells.	
Open	647	
Closed	516	131 elongation
Broken	581	65 return.
Open	637	
Closed	509	128 elongation
Broken	579	70 return.
Open	632	
Closed	491	141 elongation
Broken	568	77 return.

Circuit.	Scale. 20 cells.	
Open	653	
Closed	465	188 elongation
Broken	579	114 return.
Open	638	
Closed	452	186 elongation
Broken	568	116 return.
Open	632	
Closed	472	160 elongation
Broken	561	89 return.

"These constitute but a small fraction of the number of experiments actually made. There are very decided indications that the amount of elongation depends on the molecular condition of the bar. For example, a bar taken from a mass used in the manufacture of a great gun at the Mersey Ironworks suffered changes on magnetization and demagnetization considerably less than those recorded here."

The following is a summary view of the Victorian railways: A trunk line of railway runs from Melbourne to the northern boundary of the colony at Echuca; another proceeds via Geelong to Ballarat, the second town of importance; a third is about to be constructed to Beechworth, near the north-eastern boundary of Victoria; a fourth is being surveyed to Hamilton, the centre of an agricultural district in the west; and a fifth has been projected to Gipp's Land, which may be called the garden of the colony, in the south-east. When these lines are completed ready access will be obtained to the most fertile districts of the country, as well as to those which abound in mineral treasures.

The report of the directors of the Watton and Thetford Company states that they have been unable to make any satisfactory arrangements with the Great Eastern for working the line. The traffic results attained thus far have not been very encouraging, the receipts on revenue account to December 31st having been £586, while the working expenses amounted to £511, leaving a balance of £75. An Act has been passed for extending the line from Watton to Swaffham, but no steps have hitherto been taken for constructing this extension line.

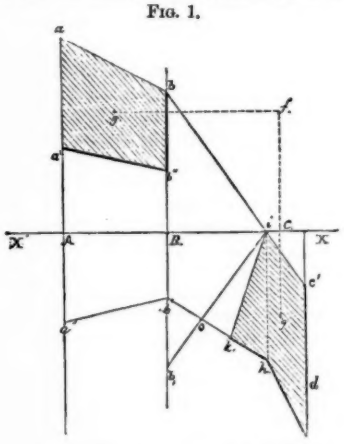
TRANSPORTATION OF EARTH.

Translated from Sonnet's "Dictionnaire des Mathématiques Appliquées."

In all constructions which require the movement of large quantities of earth, such as the establishment of a road, railroad, or canal, two questions have to be solved: one consisting of the determination of the mean distance of transport of earth, the other of the most advantageous *organization* of this transport. We shall first consider the former.

If V is the total volume necessary for a given cutting, the cost of transport is proportional to V; but it will also depend upon the distances to which the different portions of the volume V must be transported. Let v, v', v'', etc., repesent the several elements of the volume V; d, d', d'', etc., the distances corresponding to these

FIG. 1.



elements; then the expense of transport will be proportial to the quantity—

$$vd + v'd' + v''d'' +, \text{ etc.}$$

Let D be such a distance that

$$vd + v'd' + v''d'' +, \text{ etc.}, = VD; \quad [1]$$

then D will be the mean distance of transport, and the expense will be proportional to the product VD. The determination of this mean distance is important.

The most simple and ordinary case is that in which the carriage is along a straight line. In this case the mean distance is the distance between the centres of gravity of the cutting and the filling. Let χ^0, χ', χ'' .... X_0 be the primitive distances of the centres of gravity of the elementary volumes v, v', v'', and of the total volume to any fixed plane perpendicular to the axis of the route; and let χ', χ'', χ''' .... X be the distances of the same centres to the same plane after transport. Then $d = \chi - \chi_0$; $d' = \chi' - \chi_0'$; $d'' = \chi'' - \chi_0''$; .... therefore, equation [1] may be written:

$$v(\chi - \chi_0) + v'(\chi' - \chi_0') + v''(\chi'' - \chi_0'') + \ldots = VD;$$

or,

$$[v\chi + v'\chi' + v''\chi'' + \ldots] - [v\chi_0 + v'\chi_0' + v''\chi_0'' + \ldots] = VD.$$

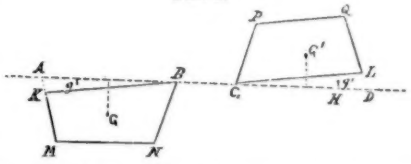
Applying the principle of moments,

$$VX - VX_0 = VD$$
$$\therefore D = X - X_0;$$

which proves the above principle.

In applying this rule, engineers generally employ a graphic method. Let $X\,X'$ (Fig. 1) be the axis of the route; and A, B, C points at which the cross-sections have been determined. Suppose

FIG. 2.



that the first profile, A, presents a section of cutting, d, and a section of filling, r; the second profile, B, corresponding sections, d and r; the third, C, a filling without cutting. If, through the point of change from cutting and filling in the profile B a vertical plane is supposed to be parallel to the axis of the route, it will divide the filling of the profile C into two parts; one, ρ, corresponding to the cutting d', the other, ρ', to the filling r'. Perpendiculars are drawn to $X\,X'$ at A, B, and C; $A\,a$, $B\,b$ are laid off proportional to the areas of the cuttings d and d'; and $A\,a'$, $B\,b'$, $C\,c'$, $D\,d'$, proportional to the fillings r, r', ρ, ρ'. Connect by straight lines $a\,b$, $a'\,b'$, $b'\,d$, and $b\,c'$. The volume of the cutting between A and B is approximately

$$\tfrac{1}{2}(d + d')\,AB,$$

and is represented by the area of the trapezoid $A\,a\,b\,B$. The volume of the filling between the same sections is repre-

sented by $A\,a'\,b'\,B$. Between the sections B and C we must first consider the volume of filling corresponding to the fillings r' and ρ'; it is represented in the drawing by the trapezoid $B\,b'\,d\,C$; we must next consider an area corresponding to the cutting d' and the filling ρ. The distance χ of the mean line of passage to the section B, being expressed by

$$\chi = BC.\frac{d'}{a'+\rho} \quad \text{or} \quad BC.\frac{Bb}{Bb+Cc'}$$

must be equal to Bi. Consequently the volume of the portion in cutting, being expressed by

$$\tfrac{1}{2}\,d'\chi \quad \text{or} \quad \tfrac{1}{2}\,Bb.Bi,$$

is represented by the area of the triangle $b\,B\,i$. The volume of filling is represented by the area of the triangle $i\,C\,c'$.

Between two consecutive sections there is a partial compensation between cutting and filling consequent upon the carriage of earth perpendicular to the axis of the route, thus requiring no longitudinal transport. By laying off the trapezoid $A\,a'\,b'\,B$ upon $A\,a''\,b''\,B$, it is seen that after the partial compensation just mentioned there will remain an excess of cutting corresponding to $a\,a''\,b\,b''$. To obtain more conveniently the total filling between B and C, which is the sum of $B\,b'\,d\,C$ and $i\,C\,c'$, draw $i\,h$ perpendicular to $X\,X'$; make $d\,e = C\,c'$, and join $e\,h$; the triangle $d\,e\,h$ is equivalent to the triangle $i\,C\,c'$, so that the total filling is shown by the polygon $B\,C\,e\,h\,b'$. Revolve the triangle $b\,B\,i$ to $b,\,B\,i$, and put for the $b'\,o\,b$, the equivalent triangle $i\,o\,k$. The figure $B\,b'\,k\,i$ is equal to $b,\,B\,i$, and the excess of the filling between B and C will therefore be represented by the figure $i\,h\,k\,e\,C$. The centres of gravity g' and g of $a\,a''\,b''\,b$ and $i\,k\,h\,e\,C$ are found. We draw $g\,f$ parallel to $X\,X'$ and $g'\,f$ perpendicular. The distance $g\,f$ is the mean distance of transport.

This method is applicable, whatever the number of profiles, by carrying from one interval to the next the excess of cutting obtained by the partial compensation made in each interval. This expeditious process gives results sufficiently approximate, especially if the drawing is made to a large scale. The centres of gravity can often be determined by inspection without great error. It is not necessary to use the same scale for distances in the direction $X\,X'$ and for the distances set off perpendicular to this axis. Ordinarily the last are taken to the scale 0m.005 per square metre; the first are taken to the scale 0m.001, 0m.002 to the metre; sometimes to a smaller scale.

There is another case in which the mean distance of transport can be evaluated very easily; that in which the cutting or filling can be divided by vertical planes into equal corresponding slices. This happens in most of the terracing work in fortification. The relief of fortified works is formed by the earth brought forward from the ditch, so that a series of vertical planes perpendicular to the direction of the *line de feu* divide the fosse and the relief into sections of the same volume. In this case the distance between the centres of gravity of cutting and filling is the same for each section; it is equal to the distance between the centres of gravity of the force and of the total relief; and this is the mean distance of transport.

In other cases this mean distance can be determined only approximately, and its minimum can be found only by *tatonnement*. In general, engineers take approximate value of the mean distance, the distance between the centres of gravity of cutting and of filling.

We have supposed the direction of transport to be horizontal. When in going from cutting to filling it is necessary to go up a rising grade, this circumstance of course increases the work. In military engineering it is assumed that 20 metres of distance on a rising grade of $\frac{1}{12}$ is equivalent to 30 metres on a horizontal; and the cost of transport is determined by this rule. Suppose b to be the horizontal projection of the distance to be passed over and h the height, the grade being 1 in 12, we have $b = 12h$; and the distance $12h$ on the rise is equal to $18h$ on the horizontal.

Let $A\,M\,N\,B$ (Fig. 2) represent the section of an excavation from which earth is to be carried to fill the section $C\,P\,Q\,D$. Through the points B and C draw the lines $B\,K$ and $C\,L$ at an incline of 1 to 12; that is, at a horizontal angle of about 4° 46′. Let g be the centre of gravity of the triangle $A\,K\,B$, g' that of the triangle $C\,L\,D$, G that of the quadrilateral $L\,M\,N\,B$, G' that of the quadrilateral $C\,P\,Q\,L$; h, h', H, H' the distances of the several centres from the horizontal $A\,B\,C\,D$; let

fall upon this horizontal the perpendiculars $g\,I$ and $g'\,H$. Consider the volumes corresponding to the same length of excavation and embankment perpendicular to the plane of the figure. Earth must be brought to the point B, carried from B to C, and spread over the entire surface of the embankment. It may be assumed that the work is the same as if the volumes were concentrated at their centres of gravity. According to this supposition, in order to bring the earth from the prism $A\,K\,B$ to B, a volume v must be moved a distance compounded of $I\,B$, horizontal distance, and $6h$, taking rise into account. The product of the volume by the distance is

$$v\,(IB + 6h)$$

while the corresponding product for carriage from B to C is

$$v.BC.$$

For transport from the point C to the several points of the prism $C\,L\,D$ of volume v', we shall have

$$v'\,(CH + 6h').$$

Let V represent the volume of the prism $K\,M\,N\,B$, and V' that of the prism $C\,P\,Q\,L$; then the product for transport to the point B is

$$V.18H;$$

from B to C the product is

$$V.BC;$$

finally, for transport from C to all points of the prism $C\,P\,Q\,L$, the product is

$$V'.18H'.$$

In order not to pass the inclination 1 in 12, the line of distribution of the volumes V and V' must be extended by making them follow the slopes made upon the interior talus of the excavation and upon the talus. These slopes are divided into lengths of 20 metres, so that each receives 10 metres of distributiom from either end. The centre of gravity of the volume received or distributed is then 5 metres from the slope. Hence 5 metres must be added to the distance of transport of each of the volumes V and V'; so that the total sum of products of volumes and distances is

$$\left.\begin{array}{l} v\,(IB + 6h + BC) + v'\,(CH + 6h') \\ + V\,(18H + BC + 5\text{m.}) + V'\,(18H' + 5\text{m.}) \end{array}\right\} \ldots [2]$$

This sum, divided by the total volume $v + V'$, will give the mean distance of transport.

The first two terms of formula [2] can generally be neglected in comparison with the other two, unless either the excavation or the embankment is broad and shallow. When these terms can be neglected, we have $V = V'$, and the formula reduces to

$$V\,[18\,(H + H') + BC + 10\text{m}].;$$

the mean distance of transport in this case is

$$18\,(H + H') + BC + 10\text{m.}, \qquad [3]$$

that is, it is 18 times the difference of levels of the centres of gravity of the cutting and the filling, increased by the distance from the edge of the cutting to the foot of the filling, increased by 10 metres.

If the ground rise from B to C, H being the difference of level of the points G and B, H' that of the points G' and C, z that of the points B and C, we have for mean distance of transport

$$18\,H + BC + 6z + 18\,H' + 10\text{m.},$$

or

$$18\,(H + H') + BC + 6z + 10\text{m.},$$

which amounts to adding, according to the rule given above, 6 times the difference of level of the points B and C.

On the other hand, if the ground descend from B to C, we should apply formula [3] without taking this circumstance into account, unless the point G' does not descend a level equal to or less than that of B, in which case it is only necessary to add $18H + 10\text{m.}$, the horizontal distance from the points B and G'. No account is taken of the descending slopes.

When the earth has to be removed only 2 and 4 metres in a horizontal direction, or from 1.6 to 2 metres in a vertical direction, the transport should be made with the shovel. For greater distances the wheelbarrow is used, and the carriage is done by relays; the quantity of earth is said to be *à un seul homme*, if a single laborer can load a barrow while another runs over a relay of 30 metres, going and returning. The quantity of earth is said to be *à un homme et demi* if it is necessary to have two loaders to one digger to feed two barrows running over the same relay. The earth can be *à deux hommes*, or *à trois hommes*. In general, if T denotes the time occupied by a pickman to dig a certain volume of earth, and t the time for a loader to load the same volume upon a barrow, the ratio $\frac{T}{t}$ expresses the num-

ber of pickers necessary that a loader may work without interruption. The number necessary to supply a wheeler is

$$\frac{T}{t}+1 \text{ or } \frac{T+t}{t}$$

and the quantity of earth is said to be to

$$\frac{T+t}{t} \text{ men.}$$

As to the length of the relay, it is determined by the following considerations: It is assumed that a wheeler can run 30,000 metres in a day of 10 hours, and that a loader can load 20 cubic metres in the same time. The ordinary capacity of a barrow is 0m.04; *i. e.*, 25 barrows to the cubic metre. If χ denotes the distance run by the wheeler while the loader fills a barrow, we have

$$20 : 0.04 :: 30000\text{m.} : \chi$$
$$\chi = 60\text{m.}$$

The half of this distance, 30 metres, is the length of the relay. This is about the same in all localities, while the capacity of the barrow varies, according to the country, from $\frac{1}{33}$d to $\frac{1}{20}$th of a cubic metre. It is desirable to know the time necessary to transport a cubic metre the distance of a relay. As the wheeler runs 3,000 metres an hour, he wheels a double relay of 60 metres in 0h.02; but in this time he carries $\frac{1}{25}$th of a cubic metre; to carry a cubic metre a distance of 30 metres, he will require a time

$$0\text{h.}02 \times 25 \text{ or } 0\text{h.}50$$

For longer distances the hand-truck *(camion)*, dumping cart *(tombereau)*, or wagon *(wagon de terrassement)* is used. The hand-truck has a capacity of 20 cubic metres, and is usually drawn by men. The relays are about 100 metres, or it requires 20 minutes to carry a cubic metre over this distance. The capacity of the dumping carts varies from 0.50 to 1.50 cubic metres; it is drawn by one or by two horses. About 20 minutes are employed in moving a cubic metre over a distance of 100 metres, by means of a cart of mean capacity, loading and unloading included.

For longer distances, wagons (or carts) are employed, drawn by horses or a locomotive, and the transport is not made in relays. At Clamart, on the Versailles Railway, the wagons had a capacity of 1.50 metres. Three horses dragged 10 of these, with a velocity of 25,000 metres, in 10 hours. A locomotive dragged 20 with four times this velocity. In each case there was a loss of 10 minutes each trip for loading and unloading. The road had an inclination of 0m.004 to the metre. On a horizontal road five horses instead of three would have been necessary.

The barrow or the truck is generally employed for distances of less than 100 metres; the dumping-cart for distances from 100 to 500 metres; wagons drawn by horses, from 500 to 2,000 metres, and for greater distances, cars drawn by a locomotive. In mountainous countries the earth is often carried on the back of a laborer or a mule; in the first case panniers are used, of a capacity of about 0m.01; in the latter case each pannier has a capacity of about 0m.04.

When earth has to be moved in a vertical direction, the shovel should be employed, if possible, for heights not exceeding 1m.65. The laborers, one above the other, at this interval, can raise, in 10 hours, 15 cubic metres to a height of about 5 metres. Another method, almost as good, is carriage by the basket, by aid of a ladder. A laborer can make 27 trips of 3 metres height in an hour, carrying in all 8.10 cubic metres a distance of 3 metres—a result nearly equivalent to the former; for, multiplying the volume by the height, we have in the first case 72.9; in the second, 75.

Sometimes panniers, called *bourriquets*, are raised by a drum. The capacity of one of these is 0.033 cubic metres. The drum is from 15 to 20 centimetres in diameter, and from 1m. to 1m.2 in length. The crank is 0m.4 long. The rope which carriers the panniers is 0.03m. in diameter. By means of this apparatus, 15 cubic metres can be raised to a height of 5 metres. A similar method is employed in tunnelling work.

The Magdeburg Lansitzer (Prussian) Railway have issued a prospectus, inviting subscriptions for 8,000,000 thalers, or £1,200,000, less 3,000,000 thalers, or £450,000, which has already been locally subscribed. The line is 106 miles in length, and is projected to complete a link much wanted to facilitate direct communication between East and West Prussia, so as to avoid the necessity of passing round by Berlin.

THE PROJECTED CHANNEL RAILWAYS.

From "Nature."

We have already considered two modes of crossing the English Channel by a railway, viz., one above the water by a bridge, and another below the water by a tunnel through the chalk. The two shores might be also connected by a submerged roadway passing direct through the water. It might be constructed either on the bottom of the Channel or at a certain distance below the level of the sea. Submerged roadways have been proposed, some of iron, others of concrete; of the former of these we shall only consider such schemes as appear to have received sufficient attention from their originators.

These structures may be simply called tubes, because of their circular shape, which is, we all know, the most favorable form to resist pressure against collapse. The various propositions for the construction of iron tubes may be divided in two classes, viz.: 1st, Schemes in which the parts of the proposed submerged tube are to be constructed on shore in certain lengths, afterwards to be united under water to form the permanent structure. 2d, Schemes in which the whole tube is to be at once built in deep water.

Among the designs which belong to the first class, the best and most elaborate is that of the late Mr. Chalmers. His design is well known from his publication on the Channel Railway, which we consider a meritorious and ingenious production. He proposes a line of tube between the South Foreland and Blanc-Nez on the French coast, with a gigantic tower—or ventilator, as he terms it—midway in the Channel in 30 fathoms of water. Having made this tower, he proposes to construct wrought-iron tubes on shore, each about 400 ft. long, closed at both ends by watertight bulkheads. These tubes are to be floated, one by one, to the tower, and to be there submerged, "being drawn down by means of endless chains passing round pulleys or drums attached to massive anchor boxes on the bottom of the Channel." The separate parts to be submerged at one operation are to have each a floating-power equal to about 100 tons. A short description is also given how the ends of the tube about to be submerged should be drawn and attached to that part already permanently secured to the tower and the bottom of the Channel.

The deep sea tower or ventilator is probably not practicable, but we consider it does not form an essential part of the scheme. The whole tube might be formed of 240 separate pieces, each 400 ft. long, and submerged without the tower by working from one shore end. The submerging and joining together of these parts in deep water would, however, be a perilous operation. No doubt this is the main difficulty of every plan of this class of scheme. In the present case it must be overcome and the operation 240 times successfully repeated, in order to complete the structure, and we may accordingly appreciate the chance in favor of the completion of this kind of submerged roadway.

Of the second class of works, viz., building the whole tube in deep water, we have but one scheme. It is the more satisfactory to observe that, of all the schemes which have been proposed with a view to establish a permanent railway communication between England and France, it is the most elaborate and complete, offering a solution on all material points in connection with this subject. The authors of this project—Messrs. Bateman and Révy—have published a full account of their scheme, and we cannot do better than refer to their work for a short description of the plan they adopt.

"Our object has been to devise a scheme by which all difficulties of operating in water should be avoided. We propose to lay a tube of cast-iron on the bottom of the sea, between coast and coast, to be commenced on one side of the Channel, and to be built up within the inside of a horizontal cylinder, or bell, or chamber, which shall be constantly pushed forward as the building up of the tube proceeds. The bell or chamber within which the tube is to be constructed will be about 80 ft. in length, 18 ft. internal diameter, and composed of cast-iron rings 8 in. thick, securely bolted together. The interior of the bell will be bored out to a true cylindrical surface, like the inside of a steam cylinder. The tube to be constructed within it will consist of cast-iron plates in segments 4

in. in thickness, connected by flanges, bolted together inside the tube, leaving a clear diameter of 13 ft. when finished. Surrounding this tube and forming part of it, will be constructed annular discs or diaphragms, the outside circumference of which will accurately fit the interior of the bell. These diaphragms will be furnished with arrangements for making perfectly water-tight joints for the purpose of excluding sea water and securing a dry chamber, within which the various operations for building up the tube, and for pressing forward the bell as each ring of the tube is added, will be performed. Within this chamber, powerful hydraulic presses, using the built and completed portion of the tube as a fulcrum, will, as each ring is completed, push forward the bell to a sufficient distance to admit the addition of another ring to the tube. The bell will slide over the water-tight joints described, one of which will be left behind as the bell is projected forward, leaving three always in operation against the sea. The weight of the bell and of the machinery within it will be a little in excess of the weight of water displaced, and therefore the only resistance to be overcome by the hydraulic presses when pushing forward the bell, is the friction due to the slight difference in weight and the head or column of water pressing upon the sectional area of the bell against its forward motion. In like manner, the specific gravity of the tube will be a little in excess of the weight of water which it displaces; and in order to obtain a firm footing upon the bottom of the sea, the tube will be weighted by a lining of brick in cement, and for its further protection will be tied to the ground by screw piles, which will pass through stuffing boxes in the bottom of the tube. These piles, will, during the construction of the tube within the bell chamber, be introduced in the annular space between the outside of the tube and the inside of the bell, and will be screwed into the ground as they are left behind by the progression of the bell. The hydraulic presses and the other hydraulic machinery, which will be employed for lifting and fixing the various segments of the tube, will be supplied with the power required for working them from accumulators on shore, on Sir William Armstrong's system, and the supply of fresh air required for the sustenance of the workmen employed within the bell and within the tube will be insured also by steam power on shore. As the tube is completed, the rails will be laid within it for the trains of wagons to be employed in bringing up segments of the rings as they may be required for the constructions of the tube, and for taking back the waste water from the hydraulic presses, or any water from leakage during the construction.

The tube will be formed of rings of 10 ft. in length, each ring consisting of 6 segments, all precisely alike, turned and faced at the flanges or joints, and fitted together on shore previous to being taken into the bell, so that on their arrival the segments may, with perfect certainty and precision, be attached to each other. The building of the tube will be commenced on dry land above the level of the sea, and will be gradually submerged as the tube lengthens. The operations on dry land will be attended with more difficulty than those under water, but all these circumstances have been carefully considered and provided for.

The precise line to be taken betwixt the English and French coasts can hardly be determined without a more minute survey of the bottom of the Channel than at present exists. It will probably be between a point in close proximity to Dover on the English coast, and a point in close proximity to Cape Grisnez on the French coast. On the line suggested the water increases in depth on both sides of the Channel more rapidly than elsewhere, although in no instance will the gradient be more than about 1 in 100. The tube at each end would gradually emerge from the water, and on arriving above the level of the sea would be connected with the existing railway systems, so that the same carriage may travel all the way from London to Paris, or, if Captain Tyler's anticipation be realized, all the way from John O'Groat's to Bombay.

The distance across the Channel on the line chosen is about 22 miles. The tube as proposed is large enough for the passage of carriages of the present ordinary construction, and to avoid the objections to the use of locomotives in a tube of so great a length, and the nuisance which would be thereby created, and taking advantage of the perfect circular form which the mechanical operation of turning, facing, etc., will insure, it is proposed

to work the traffic by pneumatic pressure. The air will be exhausted on one side of the train and forced in on the other, and so the required difference of pressure will be given for carrying the train through at any determined speed. Powerful steam-engines, with the necessary apparatus for exhausting and forcing the air into the tube, will be erected on shore at each end; and supposing one tube only to exist, the traffic will be worked alternately in each direction.

It has been found by calculation, that, for moving a large amount of tonnage and a great number of passengers, the most economical arrangement will be to send combined goods and passenger trains through the tube at 20 miles an hour, with occasional express trains at 30 miles an hour. Thus an ordinary or slow train would occupy about 66 minutes in the transit, and a quick or express train about 45 minutes. In this way the tube, if fully worked, would permit the passage of 16 ordinary slow trains (8 each way), and 6 express trains (3 each way), each conveying both goods and passengers. About 10,000 tons of goods per day, or upwards of 3,000,000 per annum, and 5,000 passengers, or nearly 2,000,000 per annum, might be taken through, or a less amount of goods and a larger number of passengers, or *vice versa*, if circumstances rendered other proportions necessary or desirable.

The horse power required for working the traffic with the above number of ordinary and express trains will be, on the average, 1,750 indicated, or about 400 nominal horse power at each end."

We should gladly have referred to many other interesting and important statements contained in this work, but our limited space does not admit of our doing so. A general idea of the proposition may be gathered from the above description of the authors, taken from the popular part of their work. The Appendix, which really contains the substance of the scheme, is too elaborate and technical for the general reader, without devoting special study and attention to it. Suffice it to state, that the amount of information conveyed in those 40 pages of close print is very great, being an account of a succession of results of elaborate investigations of a physical, mathematical, and even of a chemical nature. One gains confidence from the mere fact, that in treating the subject the authors are evidently "at home," and do not evade a difficulty.

The general principle of the scheme, as invented and elaborated by Messrs. Bateman and Révy, may be easily understood by the ordinary reader. He can, however, have little idea how the practical difficulties attending the execution of such immense works have been overcome by these engineers. Take, for example, the first sentence or two we have quoted above. The general proposition is this: "A tube of cast-iron to be built up inside a horizontal cylinder or chamber." No doubt this may appear simple enough, but when we come to consider what the operation of *building* means; when we come to consider that no part of the tube to be so built up weighs in one piece less than 10 tons; that those solid pieces of iron could not even be stirred by the power of scores of men, much less lifted or deposited in the right place; that this "building up" is to take place in a comparatively small space, not exceeding 13 ft. in diameter, the larger part of which is already occupied by the very plate weighing 10 tons,—we may in a measure realize what the word "building" under these circumstances signifies.

But we have further to bear in mind, that it is not enough that we should be able somehow to "build up" the tube inside that chamber, but that it must be done quickly, without delay or a hitch, and that unless it could be so done the operation of "building up" would take generations in crossing the Channel, and make the whole proposition, though practicable in every detail, yet a forlorn hope, because of the length of time. If thus we come to consider, that the authors have not contented themselves with saying that "their tube is to be built up in that chamber," but have given us the precise designs and the exact mode of proceeding to be adopted; that the designs and arangements are so complete that they might be forthwith placed in the hands of a contractor; that these mechanical arrangements would enable a boy of ordinary intelligence to take hold, lift, and place, and finally deposit these monster plates with the same ease, quickness, and certainty as a bricklayer would lay his brick in the construction of an

arch, we venture to say the authors have made out their case.

We believe it is the first time that any of the projectors or designers of Channel railways have paid serious attention to the important question, how such a submerged railway or tunnel could be used and worked to advantage for the enormous traffic between England and France. Most of them seem to assume, as a matter of course, that such a tunnel of iron or brick would be worked as ordinary railways. It appears, however, from in the investgations of Messrs. Bateman and Révy that there is but one way of working such a tunnel to advantage, and unless the arrangements and the construction of the works be kept in accordance with that mode of working the traffic, the tunnel, when completed, would be of no use for practical purposes. The authors find that the power for the propulsion of the trains must be pneumatic pressure ; not as applied in the old-fashioned style above ground, and known by the name of atmospheric railways, but a pressure of air applied by powerful pumps directly upon the train, which would form a kind of loose piston inside the tube. On the old plan, the train was outside a little tube ; on the new plan, the train is inside a large tube ; and with this simple alteration all the difficulties which led to the abandonment of the former, disappear on the latter plan. The difficulties of the old atmospheric railways were : (1) Mechanical difficulty of connecting the piston of the little tube with the train outside it ; (2) The high pressure required on the small area of the piston for the propulsion of the train, and consequent development of an excessive amount of heat within the pumps, leading to their rapid destruction and great loss of power by subsequent cooling of the air. By the new mode of atmospheric propulsion all these difficulties are done away with, for there is no connection between a piston and the train wanted, and the pressure of the air over the large sectional area of the tube required for propulsion is but a small fraction of that formerly employed ; there is, consequently, no heating, no inordinate wear and tear, and no loss of power. Equally ingenious is the construction of the proposed air-pumps. Very large volumes of air are wanted to accompany and press forward the train—several hundred thousand cubic feet per minute. And what is the nature of the pumps to supply these? Are they to be blast engines? No ; they are to be air-pumps, in the shape of gasometers. We are all familiar enough with the sight of gasometers, but their application for such a purpose is certainly new.

We find throughout the work the same invincible spirit which seems to seek a difficulty for its immediate destruction. That a permanent railway across the English Channel will be built, we doubt not ; we are equally confident that Messrs. Bateman and Révy's scheme is a practicable solution of the problem. No less an authority than the Emperor Napoleon III., after mature consideration of the scheme, wrote to say : "*C'est le seul realisable*," and as the design is one that belongs essentially to England, His Majesty's opinion acquires enhanced value and importance. Let us, then, hope that the engineering and enterprising power of this eminently engineering country will heartily support, advance, and improve the plan, which seems to insure inestimable advantages to England and France.

STEAM LIFESHIP.—Captain Hans Busk exhibited at the *conversazione* of the Royal Society on the 5th inst. a model of a steam lifeship, which he offers as likely to render good service where the lifeboat fails. The lifeship, with a crew of 30 men, is to keep the sea, and in case of falling in with a vessel in distress would render assistance from the windward, which would be easier and often more effectual than when borne from the leeward in the teeth of a gale by a lifeboat. The lifeship could "warp down" a boat to a helpless vessel, or, approaching near and dropping anchor, could fire a rocket and send a line with the wind, and so establish communication.

LARGE quantities of bittern containing bromine are allowed to run to waste at the salt works in the valley of the Saginaw, in Michigan. This fact suggests a profitable industry for some one who can devise a convenient mode of extracting this valuable element.

STEAM POWER IN MILLS.

From "Engineering."

We have on several occasions lately protested against the employment, in mills and other situations where steam-power is permanently required, of steam engines and boilers of faulty design; and we have pointed out how—even in establishments of moderate size—the use of such engines leads to the wasteful expenditure annually of sums which, if allowed to accumulate at interest, would in a few years reach enormous amounts. Early in the present year, also, in an article entitled "The Cost of Steam Power," we gave a general outline of the matters which should be taken into consideration in choosing an engine for any given work; and on this subject we propose to say a few more words here, our remarks being especially intended to apply to the case of mills where spinning or similar operations are carried on.

In such mills, a matter of even greater importance then economy of fuel is a motion as perfectly regular as possible, and this requirement has indirectly exercised an important influence upon the economical working of mill engines. Until within the last few years almost the only form of engine to be found in such mills as those of which we are now speaking was the beam engine; a form of engine quite unfitted for running at any but at a very moderate speed, and which, therefore, if of the single cylinder class, could not—unless fitted with an enormously heavy fly-wheel—be worked at anything like a high degree of expansion without producing an objectionable irregularity of motion. In this respect, as in many others, the compound beam engine possesses a decided advantage over the single cylinder engine for mill purposes, and we are not surprised to find that the practice originated by McNaught, of "compounding" single cylinder beam engines by the addition of a high-pressure cylinder is every day gaining ground in our manufacturing districts. The manner in which the "compounding"—as it is generally called—is carried out, varies considerably. In the majority of instances, probably, the high pressure-cylinder is placed between the main centre and the crank shaft on McNaught's original plan; but in many instances, a horizontal high-pressure cylinder is placed by the side of the existing low-pressure one, the piston of the high-pressure cylinder deing coupled by a connecting rod to an independent crank on the crank shaft of the original engine. Mr. John Ramsbottom, of Leeds, also has "compounded" a number of engines by substituting for the existing single cylinder a group of three cylinders, placed side by side; the two outer ones, which are of smaller diameter than the other, being the high-pressure, and the central one the low-pressure cylinder. In this arrangement, which is a very neat one, the three piston rods are attached to one crosshead, which is coupled to the parallel motion in the usual way. In connection with this arrangement of cylinders, Mr. Ramsbottom uses a peculiar form of valve, of which we may have something to say at some future time, but which we cannot describe here. When McNaught's arrangement is employed, or when a horizontal high-pressure cylinder is used in connection with the beam engine, there is of course a considerable loss of effect due to the length of the passages connecting the high and low pressure cylinders; but, notwithstanding this loss, the practice of "compounding" has, by rendering permissible the employment of higher pressures of steam and greater expansion, effected an important economy in the vast majority of instances in which it has been resorted to; while, in cases where it has not been successful, the failure has in almost every instance been due to the faulty manner in which the principle has been carried out. We heard of an instance a few weeks ago, where it was complained that no good had resulted from the "compounding" of a beam engine, and where it turned out, on inquiry, that the high-pressure cylinder had been made of the same capacity as the existing low-pressure one! We tru t, however, that there are few such cases as this.

At best, however, the beam engine is but a clumsy machine, and it is being rapidly supplanted for all purposes by direct-acting engines of the vertical or horizontal classes. Where only a small power is required, it is in many instances difficult

to choose between the two varieties last mentioned; but in the case of large powers, the horizontal engine possesses many advantages which render it superior to every other form. As compared with the beam engine, it is of less first cost, requires less expensive foundations and engine house, and can be run at a greatly higher speed, while, if properly constructed, it is at least equally durable. The time was when mill-owners had a strong prejudice against horizontal engines, but this prejudice is rapidly dying out, and we feel sure that but few years will elapse before such engines are used to the exclusion of almost all others for mill purposes.

The high speed at which well constructed horizontal engines can be safely driven renders it possible to work them with a high degree of expansion, even if they have but a single cylinder, without producing any great irregularity of motion; but where that regularity is of such vast importance as it is in the mills of which we are now speaking, the compound horizontal engines undoubtedly give the best results, while there is also good evidence to be had of their highly economical working. Amongst the firms who have adopted such engines as these, and who have become convinced of their advantages, we may mention here Messrs. John Crossley & Sons (Limited), of Halifax. Messrs. Crossley are well known, not merely from the high position they hold amongst our manufacturers of textile fabrics, but also from the munificent charities of the senior partners in the firm, and they rank amongst the largest employers of steam power in the kingdom. Besides their principal establishment—the Dean Clough Mills, Halifax, where nearly 5,000 hands are employed—they are the owners of the Albion and New Bank Mills at the same place, and of the Holmfield, the Shay-lane and the Dapper Mills in its immediate neighborhood; and, according to their latest returns, when we visited their mills a few weeks ago, the aggregate power of the engines at these mills amounted to 3,369 indicated horse power. Of this vast power no less than 2,287-horse power was being utilized at the Dean Clough Mills alone, while another engine, intended to indicate between 700 and 800 horse power, is in course of erection at the same establishment. Like the majority of other large mill owners, Messrs. Crossley, until within the last few years, employed beam engines exclusively, and as it happened all their engines were of the single cylinder type. About three years ago, however, they commenced to "compound" their engines, and at the present time the engines at the Shay-lane, the Holmfield and the Dapper Mills, as well as a pair of beam engines at the Dean Clough Mills, have been thus altered. The remaining engines at the latter mills are a pair of beam engines, which are now being "compounded" on McNaught's plan, by Messrs. Pollit & Wigzell, of Sowerby Bridge, and which will shortly be worked with Howard's boilers at 140 lbs. pressure; and a pair of compound horizontal engines, with cylinders 20½ in. and 41 in. diameter respectively, the stroke being 5 ft. These latter are run at a speed of 48 revolutions, or 480 ft. of piston per minute, and at the time of our visit were indicating 826-horse power.

So far, we have spoken of the engines only, but it is in the pressure of steam which Messrs. Crossley are employing to work some of their engines that their practice is particularly distinguished. It is not so very long since 30 lbs. per square inch was thought a high pressure of steam to use in mills; but of late years pressures of 50 lbs., 60 lbs., and even 70 lbs. per square inch have become common. Messrs. Crossley, however, have made a great advance on this, and the steam for their engines at the Shay-lane and Dapper Mills is being supplied at 140 lbs. per square inch, while two boilers at the Dean Clough Mill are being worked at the same pressure. Of course no boiler of the ordinary Lancashire pattern could be worked at such a pressure as this, and to enable them to use such pressures, and at the same time obtain perfect safety, Messrs. Crossley resolved to use the well-known Howard safety boiler. Accordingly, about two years ago they put down a boiler of this kind at their Dean Clough Mill, and, its performance proving eminently satisfactory, the boilers at the Dapper and Shay-lane Mills were replaced by Howard boilers, and another of the same class was started at Dean Clough. The more extended experience with the Howard boilers bearing out that originally obtained, Messrs. Crossley are now adopting these boilers still more largely, and, in addition to the six already men-

tioned, Messrs. Howard have on order and are erecting nine others at Dean Clough, all of 50-horse power each, while they are expecting orders for nine more to replace existing boilers at the same mill. The boiler first erected by Messrs. Howard at Dean Clough was about twelve months ago tested against one of the Lancashire boilers at the same mill, and the results obtained are worth noting. The Lancashire boiler was 30 ft. long, 7 ft. in diameter, and had two 2 ft. 9 in. flues. It was fired by a Juckes's grate arranged beneath it, the grate area being 26 sq. ft., while it had a total heating surface about 900 sq. ft., or—reckoning two-thirds of the internal and half the outside flue surface as effective—an effective surface of about 600 sq. ft. The Howard boiler, on the other hand, consists of eight bottom tubes, 10 in. in diameter by about 11 ft. long, and 104 vertical tubes, 7 in. in diameter and 5 ft. long, these tubes being disposed in eight rows. The fire-grate, which has an area of 30 sq. ft., is disposed beneath the horizontal tubes. The water level is about 2 ft. from the top of the vertical tubes, and the total surface exposed to the fire and the hot gases is 1,063 sq. ft., of which 381 sq. ft. is superheating surface. Reckoning half the vertical surface as "effective," the total of the effective heating and superheating surface is 587 sq. ft.

In the trial the Howard boiler was worked for 10½ hours, and during that time 49,300 lbs. of water were evaporated by the consumption of 6,944 lbs. of coals, 7.009 lbs. of water being thus evaporated per pound of coal. The trial of the Lancashire boiler, with Jukes's grate, lasted 63 hours, and during that time 222,900 lbs. of water were evaporated by 37,804 lbs. of coal, the evaporation being thus at the rate of 6.4 lbs. of water per pound of coal. The coal used in each case was weighed, and the water carefully measured; the description of coal used, namely, Sharlston, in the two experiments was identical, but the Lancashire boiler had the advantage of being fed with water which had been passed through a Green's "economizer," and which, in consequence, entered it at a temperature of 160 deg., while the Howard boiler was supplied with cold feed, a disadvantage which would reduce its performance quite 8 per cent. Notwithstanding this, it gave, not only a higher evaporative efficiency, but it evaporated a greater quantity of water per square foot of heating surface, as the following analysis of the results will show:

	Howard boiler. lbs.	Lancashire boiler. lbs.
Water evaporated per pound of coal	7.009	6.4
Water evaporated per hour	4695	3395
Water evaporated per hour per square foot of total heating surface	4.416	3.77
Water evaporated per hour per square foot of effective heating surface	8.0	5.77

In the above data the superheating surface of the Howard boiler has been included as part of its heating surface. If, however, we exclude this superheating surface the evaporation per square foot of effective surface would be raised to 11.85 lbs. per hour. The superior evaporative power of the Howard boiler was no doubt due to the excellence of its circulation, and to the consequent freedom of the heating surfaces from scale. Indeed, one of the tubes from the very boiler in which the above experiments were made was taken out last week for examination, after having been in use two years, and it was found perfectly free from incrustation. Considering that the water at Dean Clough is far from being of good quality, and that it is found to form a very hard deposit in the Lancashire boiler, this result is worth noting.

It is not our intention to write here of the Howard boiler, but the results which have been obtained with it at Messrs. Crossley's mills bear so directly upon the subject to which this article relates, that we feel compelled to notice them. We have spoken of the benefits to be derived from "compounding" engines, and in the practice at Messrs. Crossley's mills there is to be found not merely evidence of this benefit, but also of the additional advantage of working such compound engines with steam at an unusually high pressure. Thus the machinery at the Shay-lane and Holmfield Mills is in each case driven by a beam engine compounded on the McNaught plan, the two engines being of identical construction. In the case of the Shay-lane Mill, however, the steam is supplied to the engine at 140 lbs. pressure by one of a pair of 50-horse Howard boilers, while at the Holmfield Mill the

steam is supplied to the engine at a pressure of 70 lbs. per square inch by boilers of the Lancashire class. In the Shay-lane engine the high-pressure cylinder is 16 in. in diameter, with 3 ft. 3 in. stroke, and the low-pressure cylinder 37 in. in diameter, with 6 ft. 6 in. stroke, the relative capacities being thus as 1 to 10.7; while at the Holmfield Mill the high-pressure is made larger in proportion to the low-pressure cylinder, on account of the lower pressure of steam with which it is supplied. In January last, a careful trial of the engine at Shay-lane showed that the consumption of fuel was 2.5 lbs. per indicated horse power per hour, the trial lasting 10½ hours, and the rakings of the fire at the end of the day being included in the quantity of fuel used. The coal employed on this occasion was local slack. In February, another trial was made with the same engine, the coal employed being "Denaby main best," and in this case the consumption of fuel was 1.894 lbs. per indicated horse power per hour, the trial lasting 10 hours, and the rakings from the fire in this instance not being included in the amount burnt. The engine on each occasion indicated 171-horse power, and the trials were made in the course of ordinary working without any arrangements for attaining special results. On the other hand, the engine at the Holmfield Mill, tried under similar circumstances, has been found to use just under 3 lbs. per indicated horse power per hour, and as the two engines are of the same construction, and the difference is too great to be accounted for by the difference in the evaporative efficiency of the respective boilers, it must be in the main ascribed to the higher pressure of steam employed at Shay-lane and to the greater extent to which expansion can consequently be profitably carried on at that mill. It is also worthy of notice that at Shay-lane an important economy of fuel was at one time found to be effected by reheating the steam on its way from the high to the low-pressure cylinder, by passing it through a steam jacketed pipe. This result was due to the fact that the feed was supplied from the waste water from the soap works in the neighborhood, thus causing the boiler to prime. Since the boiler has been supplied with pure water the priming has ceased, and the use of the superheating arrangement just mentioned has been discontinued, as, now that the steam is pure and dry, its employment has been found to produce no sensible effect on the fuel account. In fact, the steam supplied by the Howard boiler is already slightly superheated.

Altogether, the results obtained at Messrs. Crossley's various mills point undoubtedly to the same conclusion as those we have advocated, namely, that the compound engine supplied with steam at a high pressure is the most economical for mill purposes, and their experience, moreover, proves that the horizontal form of engine is not only of considerably less first cost, but can be maintained with certainty at as low an expenditure as the beam engine. Of the new horizontal engine which is now being erected at the Dean Clough Mills, by Messrs. Pollit & Wigzell, of Sowerby Bridge, from the designs of Mr. Richard Hanson, Messrs. Crossley's engineer, we propose shortly to publish engravings; but we may, nevertheless, give some particulars of it here. The high and low-pressure cylinders and the air pump are placed in a line, one behind the other, the two cylinders being respectively 15 in. and 45 in. in diameter, with 4 ft. stroke. The engine is to be run at 75 revolutions, or 600 ft. of piston per minute, and it is to indicate about 500-horse power at present, which will no doubt be about the most economical load; but it is to work up to 800-horse power when required. The steam will be supplied at a pressure of 140 lbs. per square inch, by three Howard boilers, these boilers only occupying a space of 25 ft. by 17 ft., these dimensions including the brick-work setting. This engine will, we understand, be started in the course of a week or so, and we hope that when we publish the description of it, we shall be able to give an account of its performance also.

A new route has been projected to India, which it is believed will be a formidable rival to that *via* Brindisi. A railway is to be built connecting the Austrian lines with the harbor of Santi Quaranta, in Epirus, *via* Dalmatia, Bosnia, and Albania. It is stated that this harbor could be made to hold a sufficiently large number of ships for the purpose, and that the country in its vicinity is capable of affording a great opening for its commercial development.

THE MORSE BATHOMETER.*

This is an instrument designed to aid submarine telegraphy exhibited by Sidney E. Morse and G. Livingston Morse, of New York. In regard to this bathometer the pertinent remarks of C. W. Siemens upon the apparatus in the Exhibition, in England, of 1862, may be quoted. He says: "New discoveries and inventions, represented most likely by some ill-executed model, will naturally occupy only a modest position among the great crowd of brilliant objects surrounding us at a great exhibition, and are overlooked or only half appreciated, until their real worth becomes gradually apparent, in the course of years, through the results they are destined to produce." This it is believed very aptly applies in the present case. The instrument referred to attracted little attention, from its unpretending size and appearance, and the jurors who examined it evidently misapprehended or overlooked its peculiarities. Its main principle was supposed to be the compression of air, which experience has long since proved cannot be successfully used as a means of ascertaining the depth of very deep water, and this erroneous impression probably turned away the attention of the jurors from the novel contrivances in this curious instrument.

The Morse bathometer is a double bathometer, by which the depth of the water in the deepest parts of the ocean may be ascertained, at one sounding, by two entirely distinct and independent methods. Messrs. Morse, in the course of their experiments, made the remarkable and, in its applications to investigations of the bottom of the sea, inestimably important discovery that small hollow glass spheres can be constructed which will retain their buoyancy in the deepest parts of the ocean, being neither crushed nor permeated by water under the enormous pressure at those great depths. They have made hollow glass spheres so light that they would float in water with more than half of their bulk above the surface, the spheres being between 3 and 4 in. in diameter, and the glass less than $\frac{1}{10}$ of an in. thick, and they subjected these light and fragile bodies, in the cistern of an hydraulic press, to a pressure of 7 tons on the square in., which is the pressure at the depth of about 30,000 ft., or nearly 6 miles in the ocean. The spheres came out from this severe trial of their strength and impermeability whole, and empty of everything but air. In the construction of their bathometer Messrs. Morse deposit these spheres, in any required number, in a tube of tin, wood, or other suitable material, the tube being commonly of 4 in. interior diameter, several ft. long, ballasted at its lower end so that it will stand and float upright in the water, and surmounted at the upper end by a conical or parabaloidal cap, having a socket on the top, in which a very light straight rod of any desired length may be securely fastened. When a sounding is to be made, an elongated weight, sufficiently heavy to carry the whole instrument rapidly down, is attached to the lower end of this upright, ballasted tube, and so attached that the moment a small weight, which moves in advance, strikes the bottom of the sea, the large weight will be infallibly detached and allow the tube, by its own buoyancy, to ascend with the rest of the apparatus to the surface. As this instrument is not encumbered with a line, or with anything causing irregularity of motion, it moves through the water with uniform velocity, both in its descent and ascent, and the time of its disappearance below the surface may, therefore, be taken as a correct measure of the depth of the water. If, for example, it should be found to occupy just 10 minutes in descending to and ascending from a depth of 1,000 fathoms, its disappearance for just 20 minutes would indicate that the depth was 2,000 fathoms. The rapidity of the descent and of the ascent of each instrument will be regulated, of course, by the amount of weight suspended from, and of buoyancy inclosed in, the tube. It can easily be made to go down and return in very deep water in less than a tenth part of the time required when a line is used.

But this bathometer, as has already been remarked, is double. In determining the depth of the water at any point,

* From the Report of Prof. S. F. B. Morse, LL.D., U. S. Commissioner to the Paris Exposition.

Messrs. Morse do not confine themselves to calculations based on the interval of time elapsing between the disappearance and reappearance of their instrument at the surface. They inclose in any convenient part of their tube, to be carried down and brought back with it, another instrument, which enables them, on its return to the surface, to mark, with the greatest precision, the true depth of the sea at the place of the sounding. This instrument, which is based on the principle of the compression of water, and is the proper Morse bathometer, is thus constructed. A glass bottle (it may be of the capacity of a pint, more or less) is completely filled with freshly distilled water, and closed at its neck with an india-rubber stopper. Through the centre of this stopper passes, longitudinally, a short glass tube of very small bore, open at both ends, and extending beyond the stopper in both directions, namely, an inch or more within the bottle and 2 or 3 in. on the outside. One end of an india-rubber tube 3 or 4 in. long, open at both ends, and, when open, of about an inch in diameter, is then passed over the neck of the bottle and made tight there by winding around it fine wire or cord, which presses it close to the glass. The bottle is then sunk in a vessel of distilled water till the water rises above the mouth of the india-rubber tube, which is held upon and open to receive it. Mercury, sufficient to fill the tube to the extent of one-half or more of its capacity, is then poured in, the mouth of the tube closed, and a cord or wire wound tightly around at the end, under water, thus converting the india-rubber tube into a bag filled in nearly equal portions with mercury and distilled water. On inverting the bottle, the mercury, from its specific gravity, occupies the lower half of the india-rubber bag and keeps the water from access to the lower orifice of the glass tube, which passes now from the bottom of the bag through the stopper into the bottle. When this bottle of water, thus prepared, is placed at the bottom of the sea, the pressure of the external sea water, acting through the india-rubber bag, and through the mercury in the bag and in the glass tube, compresses the fresh water in the bottle, and the mercury is forced from the bag into the bottle to fill the void caused by the compression. The quantity of the mercury forced into the bottle is a perfect measure of the extent of the compression of the water, and this compression is always exactly proportioned to the height of the compressing column—that is, of the depth of the sea. It is only necessary, therefore, to measure the mercury forced from the bag into the bottle to know with the greatest precision the depth of the sea at the lowest point of descent of the bottle. To facilitate the measuring of the mercury, Messrs. Morse, in constructing their bottle, cause a glass tube several inches long, of even bore and closed at the outer end, to be inserted in the end of the bottle opposite to the neck, so that on inverting the bottle the mercury, which at first rests in the neck on the stopper, falls into this metre tube, which is graduated, and thus shows the depth of the sea by the height of the mercury, as in the barometer and thermometer the height of the mercury indicates the weight and heat of the air.

As the bulk of all liquids is greatly affected by temperature, as well as by pressure, the indications of any bathometer based on the principle of the compression of water, in the construction of which this consideration has been overlooked, will be wholly unreliable. Messrs. Morse have guarded effectually against all error from this source, as the bottle containing the water which they compress is kept during the whole period of every sounding in a small wooden case surrounded by ice, and the temperature of its contents, therefore, is always precisely 32 deg. of Fahrenheit. It is, of course, not necessary to send down a deep-sea thermometer with their instrument.

The following are among the advantages of the Morse bathometer:

1. *The rapidity with which it does its work.*—Six hours and more, it is said, are commonly consumed in paying out and hauling in a line with a sinker attached to it in water 2,000 fathoms deep. The Morse bathometer, it is estimated, can be made to go down to this depth and return in less than thirty minutes.

2. *The certainty of its operation.*—When properly constructed, it can never fail. The various contrivances for sounding the sea by sinking weights or instruments, which are raised again with a line from the bottom, fail so frequently in very deep

water that explorers have now abandoned the trial of them there, and it seems to be generally admitted by scientific men that in the greatest depths of the ocean no reliable sounding has ever yet been made. In the Morse bathometer the weight always carries the instrument to the bottom; the detachment of the weight at the bottom is made by their device perfectly certain, and when the weight is detached the rest of the apparatus can never fail to rise to the surface.

3. *The Morse bathometer is automatic.*—The momentary attention of a single operator is all that is necessary to effect a sounding in the greatest depths of the ocean. He puts ice into the case with the bottle, marks the latitude and longitude on the tube, screws the long, straight rod into the socket at the upper end of the tube, hangs the weight on the hook at the lower end, and drops the instrument into the sea. It then takes care of itself. By its own power it moves, rapidly and uniformly, from the surface to the bottom, deposits its load there, and returning as rapidly, or (if desired) more rapidly, to the surface. The operator need not even wait to pick it up. The tube, with the bottle which it encloses and the rod which rises from it into the air, will live and ride triumphantly above the surface, amid the lashings of the waves and winds of all the storms it may encounter, and whoever picks it up at any time or at any place, however distant, may know, merely by examining the bottle, the true depth of the sea at the point marked on the tube, and may publish the information to the world. If he chooses he may then mark on the tube the time when, and the latitude and longitude of the place where, the instrument was picked up, adjust the bathometer by dropping the mercury into the bag, and re-inserting the stopper in the neck of the bottle, put ice in the case, hang a new weight on the hook of the detaching apparatus, and cast the whole apparatus again into the sea, to be again picked up by another person at another place; and thus one instrument, in process of time, may be used to make scores or hundreds of soundings, at the cost for each sounding of only the bag of sand required to sink the instrument, the few ounces of ice that surround the bottle, and the few minutes of time occupied in readjusting.

4. *The mathematical accuracy of its marks of depths.*—The Morse bathometer in its indications of depth is not affected by currents. A line, during the long time consumed in its descent, may be so swayed by currents and counter-currents that a length of twice, and more than twice, the perpendicular depth of the water may be required to reach the bottom. The measure of the depth of the sea by a line is therefore eminently unreliable; but this instrument, constructed on the principle of the compression of water, which is always precisely as the perpendicular height of the compressing column—that is, as the depth of the sea, without regard to currents—must mark this depth with scientific precision.

5. *The cheapness of the instrument.*—A tin tube a few feet long and three or four inches in diameter; four or five hollow glass spheres of a size adapted to the tube; a small glass bottle in a wooden case; three or four ounces of mercury; a light fishing rod, ten or twelve feet long, with any glittering substance at the end that will attract attention at a distance; and a twenty-pound weight, which can be made for a dime by casting plaster of Paris into the form of a long narrow bucket, and filling the bucket with sand or stones—these are the items in the cost of an instrument with which the greatest depths of the ocean can be sounded, quickly, certainly, automatically, and with perfect scientific exactness.

Is it too much to expect that, with the facilities afforded by this instrument, we shall soon have at least one sounding on every square mile accessible by ships of the three-fourths of the surface of the earth covered by water, and that with these soundings artists will construct a perfect model of the bottom of the sea, in which all its depressions below the level of the surface will be minutely and accurately represented? How long will it be before we can have an equally accurate map-in-relief of the one-fourth of the earth's surface that rises above the water? Not until man has visited every square mile of Centra Africa, of Central Australia, and of every empire, and every island from which he is now excluded by inhospitable climates and inhospitable men.

Strange! that the bottom of the sea—the widest field of the geographer, three-fourths of his entire field, hitherto covered with a thick veil, defying all attempts to

penetrate it—should at last, by such simple means, be opened everywhere for the investigation of everybody, so that the true shape of its whole vast expanse can now be more readily, accurately, and minutely dotted down on paper, and represented in sculpture, than the true shape of any large district of the dry land inhabited by man and revealed daily in the light of the sun!

PUDDLING FURNACES.

From "The Engineer."

We are unable to say how many puddling furnaces are at work in Great Britain, for the simple reason that no statistical investigation of the question has ever been undertaken; but it is quite certain that the number must be enormous. It follows, as a consequence, that even a very small reduction in the consumption of coal by each furnace would represent a considerable saving in the cost at which English wrought-iron is produced—a reduction so great indeed, that on its existence or non-existence may in great measure depend the prosperity of the iron trade. Therefore, it is not remarkable that hundreds of patents have been taken out for improvements in the construction of puddling and reheating furnaces. It is somewhat noteworthy, however, that none of these patent furnaces are generally used, while the universal adoption of any one or two is apparently as far off as ever. The typical puddling furnace of the present day is precisely the same as the typical furnace in use twenty years ago. Some cause must account for the existence of this fact; let us see if it be possible to determine the precise nature of the cause.

Every ton of iron puddled in Great Britain may be taken to represent the combustion of 22 cwt. of coal. It is true that in some districts it is less, but in others it is more, and unless special precautions are used when certain qualities of coal are burned, it may be very much more, in some cases as much as 40 cwt. of coal being required to puddle a ton of pig-iron. We believe that most managers will agree with us when we state that 22 cwt. of coal per ton of iron puddled is rather under than over the average consumption. That this is a greater quantity than is needed either in theory or practice, is to a certain extent proved by the fact that hundreds of tons of iron have been puddled with as little as 15 cwt. or 16 cwt. of coal to the ton.; and it is quite possible that even this quantity, small as it is by comparison, is still greatly in excess of that which might be made to suffice. So far as we are aware no experiments have been undertaken to determine exactly how little coal would suffice to puddle a ton of iron. It would appear that the only work required from the fuel on the grate is done when the pig has been melted, that is to say in about thirty-five to forty minutes after the charge is introduced. The entire operation lasts about eighty minutes, when the iron is good, so that it may be safely assumed that one-half the consumption of fuel takes place after the pig is melted. Dealing first with the weight of fuel burned in melting the pig, we find that the consumption is extravagantly high, amounting as it does, from 9 to 11 cwt. per ton of pig. In a good cupola from 8 to 9 tons of pig-iron can be melted with one ton of coke when in full work. It follows, therefore, allowing about 14 cwt. of coke to be equivalent in calorific efficiency to 1 ton of coal, that 11 cwt of coal should melt about 3 tons of iron instead of 1 ton. At the most, 4 cwt. of coal should be sufficient to melt a ton of iron. When iron is melted in the puddling furnace about three times as much fuel is consumed as when iron is melted in the cupola. Of course this must be taken as a general statement strictly true under most circumstances, but more or less inaccurate as regards certain exceptional circumstances which will suggest themselves.

Apparently great economy would be secured by melting the pig in a separate cupola and running it into the puddling hearth in a fluid state. This done we save—on paper—6 cwt. of coal, or thereabouts, per ton of iron puddled. It is not remarkable, therefore, that the scheme has been tried over and over again. It has, however, been invariably abandoned,

and we cannot now call to mind the names of more than one or two British establishments where it is the practice to melt pig for puddling, in a cupola. A great objection lies in the difficulty of so arranging the cupola and the furnaces that one of the first can feed several of the latter. In point of quality, too, we understand that iron thus treated is not equal to that made in the ordinary way; but a most unaccountable fact is, that the saving of fuel effected in practice is little or nothing, because the period which elapses after the iron is introduced into the furnace, and before it comes to a boil, is nearly the same, whether it is introduced cold or melted.

One great cause of the excessive consumption of fuel in puddling furnaces lies, no doubt, in the variable temperature maintained in them. At one time we have the damper up and the furnace urged to the utmost, at another the damper is down and the heat reduced. Next we have the fire door opened while the balls are being withdrawn, during which time no fuel is placed in the grate, while large volumes of cold air rush in. Lastly, a lot of cold pig for the next charge is introduced; the temperature must fluctuate within a range of at least 1,000 deg., and those practically acquainted with furnaces will best understand how much fuel is wasted in the attempt to get a furnace which has "gone back" up to the right pitch again. It is obvious that as these changes of temperature are practically independent of the weight of iron in the furnace, economy should follow on each increase in the weight of iron dealt with; but 4½ cwt. is about the most one man and his underhand can deal with at once. The double furnace was introduced to dispose of this objection. It is worked by 2 men from opposite sides, and the charge is about 9 cwt.; the consumption of coal is greatly reduced, but it is not found that any great advantage follows. The double furnace is exceptional, notwithstanding its economy, for reasons so well explained by Truran years ago, and so true in the present day, that we reproduce them: "It is difficult to get the puddlers to work to time. Unless this be done, no advantage is gained over the single furnace. If one be kept waiting for ever so short a period by the other, the loss in iron more than counterbalances the reduced consumption of coal. This difficulty of obtaining men who will work thus in concert, has operated against the use of double furnaces. Were it not for this circumstance they would entirely supersede the single furnace." The writer of the passage we have quoted might have added that the fault lies not so much in want of will on the part of the men, as in difference of physical capacity and skill. It is not that they won't do what is wanted, but that they can't. The double furnace, we may add, supplies an admirable illustration of the difference between sound theory and sound practice. It is a failure from causes of which the theorist would not take any cognizance whatever, and it is from, in a sense, similar causes that hundreds of patent furnaces have disappointed the hope of their inventors.

So far we have dealt with the consumption of fuel during the first stage of the puddling process only; and we have assumed it to represent about half the total consumption, because although the subsequent stages of the process occupy a much longer time, the damper is kept down from the moment the iron begins to come to nature, and the rate of combustion is accordingly reduced. It is somewhat strange, regarding the phenomena of puddling from one point of view, that any fuel whatever should be required during the latter stages of the process. The Bessemer process has taught the world that the combustion of the carbon contained in pig-iron is sufficient, not only to maintain it in a fluid state, but enormously to increase its temperature. The process of puddling, or, more strictly speaking, of boiling iron, is analogous to Bessemerizing. Why, then, should not the oxygen proceeding from the fettling, and absorbed from a flame abounding in free air, suffice to bring about a similar result? We are not aware that any completely satisfactory explanation of the fact that it does not has ever been offered. Twenty minutes suffice for the blowing of a charge in the converter. To puddle a charge occupies about twice as long, though the absolute work of giving out the carbon is effected in less time. The prolongation of the process, such as it is, will hardly account for the fact that the combustion of the carbon in the iron in a puddling furnace is not attended with the same phenomena as those present in the

converter. It may be that the presence of a large quantity of iron—4 or 5 tons—in the converter, instead of 4 cwt. or 5 cwt., as in the puddling furnace, will satisfactorily explain the fact, as it is well known that, other things being equal, the greater the quantity of fuel burning at once the higher is the temperature produced; and it is not impossible that a proportion of the economy proper to the double furnace, is due to the more favorable conditions under which the carbon is burned out of the iron. If this be so, it follows that any system of machine puddling which would permit large quantities of iron—say 3, 4, or 5 tons—to be dealt with at once, would introduce means of economy not hitherto thought of.

We have now to consider how it is that some reverberatory furnaces work with much less fuel than others. To deal with this point in full would extend the length of this article too much. We shall return to the subject; but, meanwhile, we may point out that all endeavors to reduce the consumption of fuel must be based on three general principles. In the first place, we must try to utilize the fuel within the shortest possible distance from the bridge; in the second place, we must produce the highest possible heat; and, in the third place, we must waste as little of that heat as may be. The multifarious questions connected with grates, stacks, draught, temperature of air, etc., we shall not now touch upon. For the present we wish to call attention to certain phenomena of heat which have not as yet received the notice they deserve. They bear strongly on the proposition that all the fuel should be utilized as near the bridge as possible.

It is commonly assumed that a body of gas once heated can only lose its high temperature in one of two ways. It must either impart its heat to some other and cooler body, or else do work. If it does neither, then the temperature should remain constant. The accuracy of this proposition we do not controvert. Yet we find in practice that gases apparently doing no work, and surrounded by non-inducting media of the same temperature as themselves, do lose heat with startling rapidity. If we take an ordinary heating furnace, and apply it to raise steam by the waste heat, we shall quickly find that the efficiency of the coal in raising steam is very much less when so employed than it would be if burned directly under the boiler in the proper way. In a locomotive engine, for example, 20 sq. ft of grate will produce 400 indicated horse-power. In a reheating or balling furnace the temperature is certainly not less than in a locomotive engine, but the so-called waste heat from 20 sq. ft. of grate will not produce anything like half 400-horse power, assuming the engines to be equally economical, even though no iron is charged. The furnace is constructed of admirably non-conducting materials, and from the nature of the case combustion is perfect. What, then, becomes of the heat on its way from the fuel on the grate to the boiler? Furthermore, every addition to the length of the furnace neck—or in other words, to the distance intervening between it and the boiler—reduces the efficiency of the waste heat in a ratio which appears to increase as the square of the length of the neck. Why should this be? The answer is, of course, that the heat is wasted by radiation from the furnace and from the neck. To this we demur to the extent of saying that the loss by radiation is not apparently sufficient to account for the total loss. Brick is so bad a conductor of heat that the naked hand may be kept with impunity on the roof of a heating furnace 9 in. thick, inside which the temperature is over 3,000 deg. The neck is thinner, it is true; but even there the radiation must be too small to account for the actual loss of heat. It appears to us that the true solution of the difficulty must be found in the fact that work is done by the escaping products of combustion; in the first place, by expanding into a large flue after leaving the comparatively narrow throat of the furnace through which they have been squeezed, so to speak; and in the second place in friction against the sides of the flues; and in the third by internal motion. On this point, however, we shall not attempt to dogmatize; we merely wish to call attention to the fact that the temperature of the escaping gases and products of combustion decreases in a very rapid ratio with their distance from the furnace. This is not theory, but practice; and for this reason it appears that long heating furnaces are likely to be much less efficient when a very high temperature has to be maintained than furnaces of the same

capacity shorter and wider. It is possible that some of our numerous readers have experimented on the fall of temperature noticeable in non-conducting flues; if so, they will contribute not a little to the general store of knowledge regarding furnaces by sending us particulars of their experiments for publication.

ON RECENT INVESTIGATIONS OF WEATHER.

From "The Mechanics' Magazine."

"It is a necessary consequence of the nature of physical science that, in proportion to its progress, its inquiries become more and more minute and refined. The first results in all its departments are not very distinct from common observation, and the discovery of a general fact is an important acquisition, though it may not be followed through all its modifications, nor the conditions under which it exists strictly defined. But, after a certain time, more remote objects come into view, a perfect knowledge of which can be acquired only by a very accurate examination; and the relations of those already known being multiplied, require to be traced with more minute discrimination. The researches of science would thus always be becoming more difficult were they not aided by the acquisitions progressively made.

"From this circumstance, however, they continually require more delicate instruments and more accurate modes of experiment; and much of the labor of philosophers is occupied in revising the more rude results of preceding periods, in ascertaining the influence of the slighter circumstances by which the objects of their inquiries are affected, and in following out those applications and those new trains of investigation which such inquiries always suggest."—"Edinburgh Review," vol. 24, p. 339.

"We are amused with the motley admixture of truth and error apparent in the works of the older authors, and the indolent acquiescence with which those errors have been copied and transmitted through succeeding ages. While we gather confidence in results which are founded on legitimate induction, we are at the same time taught a salutary scepticism with regard to those theories which rest on less direct evidence. We learn what difficulties impede us in the very outset of our inquiries; how laborious and arduous is the task of collecting accurate observations; how liable we are to delusion from the magic power of imagination, which persuades us that we see what we expect or desire in the guise of reality, and which insensibly lures us into partial or exaggerated statements. A conjecture thrown out at random has sometimes reached the threshold of an important discovery, which has yet remained unexplored till a long time afterwards, when inquiry has led to it by a very different path. Truth often lies concealed near the very spot where we had looked for her in vain; her subtle essence eludes our grasp in a thousand ways; and even when fully in our view, she appears in such unexpected shapes and fantastic disguises, that we fail to recognize the object of our search."—"Edinburgh Review," vol. 25, p. 389.

If one science more than another exemplifies the validity of the philosophical generalizations on the progressive nature of science, or systematized knowledge, so ably set forth in the above quotations, it is that of meteorology. Essentially a science of observation, founded upon ocular views of phenomena, worked up by instrumental experiments, the multiplicity of laborious investigations which have been made with its accumulated data have again and again served but to show the absolute necessity of greater accuracy in instruments and processes of observing and of collating data, till its progress has at length tended to exhibit the correlation of its varied phenomena, which it has become evident we cannot hope to understand completely without the utmost refinement, both in instruments and methods of reseach. In various essays in the "Mechanics' Magazine," during the last two years, the attention of its readers has been directed to a meteorological law of the utmost importance, not only as a corroboration of the correlation of phenomena, but also as a formula of knowledge and a means of weather prevision. It is scarcely yet

generally known that there is a simple relation between the wind systems of our globe and the distribution of atmospheric pressure, that there can be no alteration whatever in the one without definite changes in the other. Nevertheless, this law is one and the same with the law of storms, which, as applied to "cyclones," has been known and demonstrated again and again during the last half century. The philosophers who established the theory of storms had dim glimpses of the universality of its fundamental law; but, wanting the means of investigation, they lacked the boldness to state it to be the law of winds. With the advance of time, observations have accumulated and improved; ideas have become conjectures; and these, submitted to the test of facts, have proved to be certainties. The stages of induction which led to the complete cognizance of this general law are full of interest, and afford a lesson in the philosophical progress of meteorology which cannot but prove instructive, and is certainly a hopeful promise of the further development of the science.

This law is at present usually associated with the names of Buys Ballot, the meteorologist of Utrecht, but it appears to us that it might, with more justice, be named after W. C. Redfield, the eminent meteorologist of New York. He appears to have been the first to assert the universality of the law of storms as applicable to all winds. The "Nautical Magazine," in 1836, published Redfield's theory of hurricanes, and his beautiful discovery that, in both the northern and the southern hemispheres, the hurricane wind, which is next to the equator, always blows from west. His theory and discovery have been amply verified in all latitudes, and they enable navigators to know the direction in which the focus of a tempest lies from a ship, and by inference, from the known usual paths which storms follow, how to avoid it. In the same magazine for January, 1839, Redfield wrote:—"To me it appears that the courses of the great storms may be considered as indicating, with entire certainty, the great law of circulation in our atmosphere; and that the long-cherished theory, which is founded upon calorific rarefaction, must give place to a more natural system of winds and storms, founded mainly upon the more simple conditions of the great law of gravitation." Writing in the same periodical so late as 1854, he further states: "As early as 1833, my inquiries led me to announce the conclusion that the ordinary routine of the winds and weather in these latitudes often corresponds to the phases which are exhibited in the revolving storms already described, and that a correct opinion, founded upon this resemblance, can often be formed of the approaching changes; and that the variations of the barometer resulting from the mechanical action of circuitous winds, and the larger atmospheric eddies, pertain not only to the storms, but to a large portion of the winds in these and the higher latitudes" (*vide* "American Journal of Science," 1833, vol. xxv., pages 120 and 129).

"At the late meeting of the American Association for the Advancement of Science, held at Cleveland, an ably elaborated paper was presented by Professor James H. Coffin, of Easton, Pa., on the relations which exist between the direction of the wind and the rise and fall of the barometer.* By a careful analysis of these effects during all seasons of the year, Professor Coffin establishes the north-eastwardly progression and left-wise rotation of a continued series of cyclones, in which are developed the same local relations between the rotary action of the various winds and the movements of the barometer that are found in the several rotary storms and hurricanes which have been subject to investigation. Thus, if I rightly appreciate the labors of Professor Coffin, the cyclonic character of the variable winds in the temperate latitudes, which had been inferred from special observations, and an extended range of geographical inquiry, is now established by a different and wholly independent method of investigation.

"The storm paths and routes of the cyclones clearly indicate also the true course of the principal circulation in the lower atmosphere on both sides of the equator. An enlarged view of these physical truths and conditions may serve to convince meteorologists and others of the necessity for a thorough revision and correction of the received views of dynamical meteorology. Such revision, I apprehend, is now imperatively required."

These quotations are so conclusive as

to the conviction in Redfield's mind upon the subject that there can be no doubt that the universality of the law of winds would have been established by him had there been available in his time the accurate simultaneous observations needed for the proof. These came with the meteorological telegraphy devised by Fitzroy, Le Verrier, and Ballot. Fitzroy based his weathercasts mainly on the theory of storms; therefore it is to be inferred he considered it applicable generally to the winds of Western Europe at least, but tacitly, for he nowhere maintains it to be the law of the winds.

In 1863, Francis Galton, F. R. S., published "Meteorographica," and, so far as we can find, it contains the first distinct statement and proof that the winds of Europe are controlled by the law. Says the author: "When lists of observations are printed in line and column, they are in too crude a state for employment in weather investigations; after their contents have been sorted into charts, it becomes possible to comprehend them; but it requires meteorographic maps to make their meaning apparent at a glance." The work explains a method of charting observations and also of representing pictorially the phenomena which they express, everything being fully illustrated by weather charts and maps for December, 1861, for the area comprised between the meridians of 10 deg. W. and 20 deg. E., and the parallels of 62 deg. and 42 deg. N., which is about 1,200 geographical miles in latitude, and about the same in longitude, including the British Isles and the whole of Western Europe. These maps testify that frequent wind currents sweep with an unbroken flow over the area; that the Alps form a barrier which the winds seldom overleap without change of direction, and that the mountains of Eastern Germany usually divert them; that the areas of barometric elevation and depression are enormous, and in their main features very regular, but they are ever changing their contours and their sections, whilst they also vary in the speed and direction of their movement of translation; that the areas of calms are invariably the centres of whirls of wind, or are situated between conflicting currents; and that there is one marked condition of temperature and cloud in connection with the wind, which is persistent, beautifully marked, and full of interest, namely, that a westerly wind is accompanied by an overcast sky and a warm temperature, while with an easterly wind the sky is pure and the cold intense. Further, they testify to the existence, not only of cyclones, but of what the author terms anticyclones. To quote *verbatim*, one universal fact is "that on a line being drawn from the *locus* of highest to the *locus* of lowest barometer, it will invariably be cut more or less at right angles by the wind; and, especially, that the wind will be found to strike the left side of the line, as drawn from the *locus* of highest barometer. In short, as by the ordinary well-known theory, the wind (in our hemisphere) when indraughted to an area of light ascending currents, whirls round in a contrary direction to the movements of the hand of a watch; so, conversely, when the wind disperses itself from a central area of dense descending currents, or of heaped-up atmosphere, it whirls round in the same direction as the hand of a watch." No allusion, whatever, is made to the enunciation of this general law, which Buys Ballot claims to have made previously. It was possibly arrived at independently, the one not knowing what the other had done; but, whether it was so or no, Galton was evidently the first to work it out by a correct method. Ballot used par valves of atmospheric pressure in his method, as will be seen farther on, and had his stations been more extended, the law would have been masked or misinterpreted. Galton used barometric readings simply reduced to the sea level, which subsequent experience has confirmed to be right.

In the same year, 1863, a pamphlet was published in London, entitled, "The Foretelling of the Weather in Connection with Meteorological Observations," by F. H. Klein, translated from the original Dutch by A. Adriani, M. D., etc. Klein was assisted in the compilation of his pamphlet with the advice and information of Dr. Buys Ballot, Director of the Meteorological Institute of the Netherlands. Nevertheless, read in the light of our present knowledge, the greater part of it is of no value, but it contains the following important statement, said to have been verified by Buys Ballot:—"It is one of the general rules concerning the force and direction of the wind that the wind will

always be in an easterly direction when localities situated to the northward of some place of observation have a high reading of the barometer; and, on the contrary, the wind will be in a westerly direction when the reading of the barometer is higher in localities situated to the southward of the same place of observation. In the first instance, the wind, without exception, is between south-east and east-north-east, whereas the westerly direction is again almost without exception between south-west and north-west. If it so happens that at the same time there is a difference of the reading of the barometer between localities situated in an easterly and westerly direction from each other, the wind in the first case will partake more of the northerly, in the other case more of the southerly direction. The future direction of the wind, therefore, may be determined by the following rule. When one has the lowest reading of the barometer to one's left hand, the back is turned to the region whence the wind will blow." It is certainly wrong to assert that the rule as thus stated determines the future wind; what it determines is the present wind merely. There can be no doubt, however, but that the law as explained by Klein is the basis of weather forecasts; only a rate of rise or fall of the barometer must be assumed, or limiting angles for oscillation and veering of wind must be assigned. We shall see, hereafter, that Mr. Strachan expounds the principles of forecast on the former assumption, and Mr. Scott on the latter. Dr. Ballot discovered the law by means of observations from four stations in Holland in telegraphic communication with Utrecht. He calculated the barometrical differences from the daily observed and the normal values of atmospheric pressure at the stations, and he went through the great labor of deducing the normal values from long series of observations made at each place, before he could put his theory to the test. It was favorable to the result that, Holland being a small country, the stations were not far apart. There being little difference of latitude between the stations, the normals were all much alike in amount, and their difference only slightly affected the investigation, but still it gave rise to erroneous notions. Thus Klein states that an ordinary difference (barometrical) north above south is less to be apprehended than an equally large difference of south above north. He was very desirous that Admiral Fitzroy should adopt the method of dealing with normal barometric values as practised in Holland. "By assiduous and carefully conducted barometrical observations, one has succeeded in constructing normal tables which exhibit for every day of the year the average reading of the barometer for the place of observation. Suppose the average or normal reading for a certain day to be 761 mm., while the barometer on that very day reads 770 or 752 mm., then, in the first instance, the reading, as compared with the average, is 9 mm. too high, in the other, 9 mm. too low; in other words, the departure from the normal is $+9$, or -9 mm. The knowledge of the origin and meaning of such departures is, therefore, highly important; it is just herein that the main difference between the system of observations adopted in Great Britain and that just alluded to and followed in Holland, exists. According to the British system, attention is chiefly paid to readings which only indicate a certain height and movement of the barometer. I think the system now generally adopted in Holland since 1860 would benefit Great Britain and Ireland." There is no necessity whatever to take any trouble about the normal values of atmospheric pressure, since the direction and force of wind are related to the existing distribution of pressure, as shown by barometers. Thus it happened that the limited extent of Buys Ballot's stations enabled him to establish on an imperfect induction the generality of an important meteorological law.

A pamphlet entitled "Principles of Weather Forecasts," by R. Strachan, published in 1867, clearly generalizes the subject, and is the nearest approach to a mathematical exposition of the law and of the principles involved in weathercasts that has yet been attempted. He explains the problem of forecasting weather by the method of co-ordinates; and shows that our foreknowledge of wind and weather would be certain did we know the rate of increment or decrement of barometric pressure that would occur in a given time; and shows the probabilities of the problem. "In 1865, according to the Greenwich observations, 74 per cent. of the

transitions of atmospheric pressure from maximum to minimum, or *vice versa*, lasted longer than 24 hours ; and, on an average, the duration of each rise and of each fall of the barometer was 2 days; 4 transitions lasted respectively, 6, 7, 8, and 11 days." "If the law of barometric variations were known, or if any law of periodicity, as regards barometric maxima and minima, could be established, then the forecasting of weather could be reduced to a very accurate system ; it would be a simple mechanical problem, and mathematicians would soon reduce it to accurate formulæ."

We have next to mention "An Inquiry into the Connection between Strong Winds and Barometrical Differences," by R. H. Scott, M.A., officially published by the Meteorological Committee under the incongruous denomination of "Non-Official Report, No. 1." It has been to us, we must confess, a work of no small labor to get a good idea of the plan and purport of this elaborate statistical inquiry. We despair of rendering the arrangements, conditions, and tabulations intelligible to our readers. Really and truly it is an inquiry into the possibility of forecasting the coming winds, and, as a corollary, the weather. The method of testing propounded is virtually a method of forecasting, and we shall best judge of it by the results to which it leads.

The investigation fully confirms the law about which we are writing, and which Mr. Scott, on the authority of Buys Ballot, says may be stated in these words :— "If any morning there be a difference between the barometrical readings at any two stations, such as Groningen and Maestricht, a wind will blow on that day in the neighborhood of the line joining those stations, which will be inclined to that line at an angle of 90 deg. or thereabouts, and will have the station where the reading is lowest on its left-hand side." It is to be noted, however, that this is an elastic expression of the law. The correct way of stating it is that the wind current flows nearly parallel with the isobaric curves, or curves of equal pressures, having the lowest pressure on the left of its course, the highest on its right, and that its velocity is related to the inequality of pressure or the distance apart of the isobaric curves.

The first inquiry is, "What is the connection between general barometrical disturbance and weather succeeding it?" The result obtained is : That if we notice on any morning a difference of 0.6 in. of barometric pressure between any 2 stations of the British system of telegraphic meteorology, the chances are 7 to 3 that there will be a storm within the succeeding 24 hours ; and the chances are 9 to 1 that any storm which sets in will be preceded by unmistakable signs of its approach, although the barometrical difference of readings may not amount to 0.6 in. at the time. This is highly satisfactory evidence of the signs afforded for storm prevision.

The other portions of the investigation are for the purpose of testing the law as applied to the different districts of the British Isles and the north and west coasts of France. Here Mr. Scott finds it necessary to assign limits for translation of air and veering of wind altogether incompatible with the statement of the law previously given. He says :—"Firstly, the whole system of isobaric curves, or the whole distribution of atmospherical pressure, is known to be subject to a motion of translation over the earth's surface, but of this motion the direction and the rate vary, from day to day, to a considerable extent, and in a manner independent of each other. Neither of these points has been as yet satisfactorily investigated.

"Secondly, the wind, especially in storms, seldom blows for many hours consecutively from the same point, but either veers or backs, the former motion being much more usual than the latter.

"These considerations show us that we must not interpret the law too strictly, but must make some allowance for translation and for change of direction. For the former, about 100 miles in any direction has been allowed ; *e. g.*, a westerly gale at Weymouth is considered to be amply foretold by an indication for a strong west-south-west wind between Brest and Penzance. For the latter an angle of 45 deg. for veering has been allowed, but no allowance has been made for backing."

The inquiry now is, "What accordance do the strong winds actually observed show with the directions over each district of the area as given by the law ?" The

winds observed were experienced within 24 hours succeeding the indication. Besides the allowance of 45 deg. for veering, a limiting angle of 45 deg. is assigned on each side of the indicated direction, making an arc of 135 deg. in favor of the indication, and of 225 deg. against it. "As regards direction, the inquiry affords a very strong confirmation of the law, as 94 per cent. of the barometric gradients recorded were succeeded by winds in the direction indicated by the law. As regards force as well as direction, the result is also in accordance with the principle laid down, especially as regards south and south-west winds, but the mean percentage of agreement is only 61."

Finally, inquiry is made as to "what amount of indication was given by each strong wind by barometrical differences in its vicinity?" But, as this is an inversion of the process involved in the previous inquiry, its conclusions, of course, ought to be, as they are, similar.

It should be mentioned that the winds under consideration are those recorded of force 8 or upwards of the Beaufort scale. The barometrical difference assumed as a sufficient indication of such a wind is 0.12 in. per 100 miles.

Mr. Strachan assumes 7 times the barometric difference (d) between places about 500 miles apart as the mean force (f) of the existent wind ($7 \times d = f$). Hence, if $f = 8$, $d = 1.14$ in. for 500 miles, or 0.23 per 100 miles, which is nearly double that assumed by Mr. Scott. It is therefore apparent that the relation of barometrical differences to wind force have yet to be investigated; and it will be found, we are quite sure, a subject of great importance. We incline to the opinion that the factor will be different for the same grade of force for wind from the different quarters.

This thorough investigation of this important law of wind may be said to have completely verified it; and Mr. C. Meldrum, of Mauritius, has since confirmed its validity for the winds of the southern hemisphere. Thus, common observation having at first given indications of it, more accurate examination with suitable data, has established it as a truth.

THE "FLUIDITY" OF SOLIDS.

From "Engineering."

There have probably been no investigations carried out during the past few years which possess a higher scientific interest than the admirable series of experiments which have been conducted by M. Tresca, on what he has aptly termed the "flow of solids." The subject is one which has been frequently noticed in our pages, and in our number for June 7, 1867, we published the valuable paper by M. Tresca, read before the Institution of Mechanical Engineers, during their meeting at Paris that year. This paper, with which many of our readers are no doubt familiar, contained a full account of the results which M. Tresca had obtained up to that date, and of the deductions which were to be drawn from them; but since then M. Tresca has devoted further attention to the subject, and it is of the results of his more recent investigations that we now desire to speak.

M. Tresca's earlier experiments had shown that when a solid body, such as a metal, was subjected to the action of a compressing force more than sufficient to overcome its elasticity it behaved more or less like a fluid, an actual "flow" of the particles taking place. The pressure necessary to produce this flow has been named by M. Tresca the "pressure of fluidity," and one of the objects of his later researches has been to determine this pressure in certain cases. Moreover, it is clear that when a solid is subjected to pressure, the action of that pressure is most intense at the point where it is directly applied, and becomes less and less intense as that point is receded from; and hence it may be assumed that there is, in fact, a limit beyond which, practically, no action whatever takes place. The area comprised within the limit just mentioned has been named by M. Tresca the "zone of activity," and another object of his more recent investigations has been to ascertain the limit of this zone in certain instances.

It necessarily follows from the assumption that the "zone of activity" has, practically, definite limits; that the resist-

ance which any given punch will experience in being forced through a given metal is also limited, and that there is, in fact, a certain maximum beyond which the resistance cannot rise, however great the thickness of the metal to be traversed may be. Let us suppose, for instance, a punch to rest upon a plate having a thickness which is very considerable in proportion to the area of the punch, and let us suppose the pressure on the latter to be gradually and steadily increased. Under these circumstances a "zone of activity" of gradually increasing size will be formed beneath the punch, this increase going on until the intensity of pressure on the latter is equal to the "pressure of fluidity" of the particular solid which is being experimented upon. As soon as this point is reached the resistance to the motion of the punch will, according to the theory we are now enunciating, cease to increase, and the latter will descend steadily, the metal flowing laterally from beneath it. This, of course, will only continue to be the case so long as the "zone of activity" is contained wholly within the thickness of the plate. As soon as the punch has descended so far that the "zone of activity" touches the under surface of the plate, the latter commences to bulge, and, there being a free outlet below, the lateral flow of the metal ceases, and the shearing action commences.

That the action above described does really take place under the circumstances we have supposed, has been proved by M. Tresca's later experiments, and we cannot but regard the fact as one of very high scientific interest. We hope in a future number to give a detailed account of M. Tresca s more recent researches, and of the deductions he has drawn from them; for the present, however, we must merely remark that the values of the "pressure of fluidity" of any material, furnished by various experiments, have been found to remain sensibly constant, and that they approximate closely to the number representing the resistance to shearing.

CLARKE'S QUINCY RAILWAY BRIDGE.*

This valuable work deserves a cordial greeting from the engineering profession, not only by reason of its intrinsic merits as a book of reference, but as marking the introduction into America of the excellent practice in vogue among European engineers, of publishing carefully prepared memoirs of their more important works. Although the engineer may congratulate himself on being free from that servile rule of precedent which is the bane of the legal profession, he cannot afford to be ignorant of the achievements of others, and though much of his most difficult work may lie in the province of invention, this invention will generally be more in the direction of improvements or former plans than in the adoption of essentially new ones. The increasing circulation of professional periodicals is the best evidence of the value which is now set on records of engineering precedents, but the descriptions for which room is found among the closely printed pages of a magazine are fragmentary and imperfect when compared with the fully illustrated volumes which are specially devoted to single important works. Such volumes have a value extending beyond their descriptive character; they are commentaries on previous constructions of similar character to the one illustrated; in them former plans are reviewed, indirectly, it is true, from no imperfect theoretical basis, but by the hard rule of tried experience, all innovations on established customs being tested by actual success or failure. Few volumes contain more valuable information on the construction of metallic arches, than the descriptive memoir of the Coblentz bridge across the Rhine; while probably the one work which gives the most complete idea of the merits and difficulties of pneumatic foundations is Vuigree & Fleur St. Denis's "Pont sur la Rhin a Kehl."

The volume before us is a work of very similar character to the two just mentioned; it is descriptive of the largest and most important of the five great railroad bridges which now span the Mississippi,

* An account of the Iron Railway Bridge across the Mississippi river, at Quincy, Illinois. By THOMAS CURTIS CLARKE, C. E., Engineer-in-Chief. New York: D. Van Nostrand, 1869.

and which was, until the very recent completion of the bridge over the Ohio, at Louisville, the longest iron bridge in the United States; the length of the bridge across the main channel alone, being no less than 3,250 ft., while over 600 additional feet of iron bridge are included in the approaches. The iron superstructure rests on masonry piers, which are built on pile foundations. The character of the work, with the exception of the pivot pier, of which more will be said hereafter, was therefore of no unusual kind; but the adaptation of these simple and well-tried methods of founding to a work of such magnitude, involved many points of interest and originality, especially as it was wished to complete the bridge at the earliest possible moment, and the works had to be arranged in such a manner as to be practically independent of the varying stages of water in the river.

Perhaps this very fact, that the foundations were of a character which every engineer must expect often to make use of, really adds to the value of the book.

Treatises on extraordinary works, in which few men are ever so fortunate as to be concerned, like "Brunel's Subterranean Masterpiece," or, "Stephenson's Great Tubular Bridges," often present themselves with exasperating readiness, to those who are trying to find a good set of working plans for a common pile-driver, or to devise some economical means of starting a foundation a few feet under water. The work before us will supply many deficiencies of this kind; its 20 plates are full of matter which may come into use upon a bridge over any ordinary stream. The extensive false-works which united the long line of piers, so that the machinery in use at one point could be transferred in a very few minutes to a remote foundation, involved a greater amount of preparation than it would ordinarily be wished to make; but the machine used for cutting off the piles, the arrangement of the suspension screws by which the masonry was lowered upon its foundation, the method adopted to bind the piles together and to protect them from scour, have nothing in their character which prevents their general adoption on works of very different magnitude from the one in question.

The book is somewhat obscure in regard to dates, but from official sources we have learned that the surveys were commenced November 21, 1866; delivery of materials began January 15, 1867; first foundation put in, September 15, 1867 first iron span raised, December 28, 1867 last pier completed, August 5, 1868; bridge opened for traffic, November 10, 1868; so that the whole time occupied, including surveys, was less than 2 years, of which 22 months was employed in preparing materials, construction, and about 14 months in actual construction after the state of the river admitted of putting in foundations.

The bridge as designed and built consists of a pivot draw 362 ft. long over all and 16 fixed spans, of which two are 250 ft. long, three 200 ft., and the remaining eleven 157 ft. each. To this must be added the bridge over the Quincy Bay, consisting of a pivot draw 190 ft. long and 4 fixed spans, each 85 feet long. The volume contains a careful review of the regimen of the Mississippi, which is illustrated by application of hydraulic formulæ and accompanied by a careful computation of the discharge area of the river at the bridge line. It is to be noted, however, that the mathematical calculations, which have been carried out with no ordinary care, are modestly placed in an appendix, where they form no interruption to the smooth reading of the text. The accuracy of their computation is forcibly illustrated in the case of Messrs. Humphreys & Abbot's velocity formula, which gave results differing from those obtained by actual measurement by less than one per cent.

In determining the method of construction of this bridge the first point aimed at, was to be independent of the varying stages of the water, so that no interruption might occur between the inception and completion of the work. This was accomplished by the use of the extensive false-works already referred to. These false-works rested on piles and extended entirely across the river, with the exception of the draw openings; a railway track was placed on each side of these works on which service-cars were run back and forth, while outer rails were also laid down, on which ran the travelling cranes used in laying the masonry and transferring the machinery from pier to pier. This immunity from high and low water

secured, the next principle followed in the preparation of the plans was the dispensing with all pumping and coffer-dam work, the doing everything above the water level which could possibly be done at that elevation, and the employment of divers to do such subaqueous work as might be absolutely necessary. The excavation was made by an endless chain dredge, the piles were cut off by a circular saw, and the masonry was laid above water and lowered by suspension screws, or, in the case of two of the piers, in floating caissons, till it rested upon the prepared pile foundations; the spaces between the pile heads was carefully filled with hydraulic concrete, the manipulation of which formed one of the chief tasks for the divers. The wisdom of this selection of plans was shown by the rapidity with which they enabled the work to be carried forward. The transfer of the heaviest machinery, the pile-driver or dredge, from one foundation to another, was the work of but a few hours; delays from leaks and overflows were impossible, and when the masonry had been completed the false-works were ready for erecting the superstructure.

The sole exceptions to the general plan of works were the two abutments and the two west piers. The two former were founded on beton, and the two piers mentioned were separated from the remainder of the bridge by the draw openings. One of them was founded on piles in a manner but slightly different from that pursued on the other foundations nearest the channel; the other, the pivot pier, was founded on four wrought-iron columns, 14 ft. in diameter, which were sunk, by dredging within them, to the bed of gravel which overlies the rock, 38 ft. below water, and filled with beton; the pier was then built in a floating caisson and sunk upon its foundation by the weight of the masonry. The building of this pier occupied about a year, and seems to have been the only part of the work on which the original expectation of the engineers were not fully realized; it is but justice to the engineer and author to say that he frankly admits, that in constructing another similar work he should wish to modify materially this part of his plan.

The stone used in the masonry was mostly brought up the river from the well-known stone quarries at Grafton, Illinois; a portion, however, was quarried at Hamilton, opposite Keokuk. The same completeness which characterized the outfit used in constructing the piers and foundations, was extended to the machinery used for unloading the stones. As fast as delivered they were piled up in positions where they should be accessible at all stages of water, and arranged in the order which would involve the least handling when the time came for placing them in the work. The form of pier adopted, while involving no marked departure from the forms in most common use, is exceedingly well proportioned and neatly trimmed, reflecting no small credit on the artistic taste of the designer.

The superstructure is entirely of wrought-iron, with the exception of the upper chord of the fixed spans, which is of cast-iron. The use of cast-iron we consider an error, for which, however, the engineer was not responsible. It was built by the Detroit Bridge and Iron Works. The plan of the main bridge is a Pratt truss in which the diagonal ties extend over two panels, while the end panels are made of double length by the use of leaning end posts, the floor being suspended from the centre of this panel by vertical rods. The depth of truss is made to vary with the length of the spans, being always twice the length of a panel, or $\frac{2}{11}$ of the full length of the 250 ft. spans, and $\frac{1}{7}$ of the length of the 157 ft. spans. The draw is fitted with a steam-engine placed in the centre above the track, by which it is turned and by which the deflection at the ends is taken out when the draw has been closed. The superstructure of the bay bridge is a Bollman deck bridge, the draw being of similar pattern, and hung over a central tower by log chains. In this bridge the vertical posts as well as the boom are of cast-iron, except that of draw, which is of wrought-iron. The abutments of the bay bridge are of the T form with an arch thrown in the T, an arrangement adapted to facilitate the construction of the foundations, but no less successful in its architectural effect. The calculations of the strains on the different members of the trusses are given in full in the appendices, and the details of construction are illustrated on the plates. In the same connection are given a number of tables of experiments on the strength of iron, which, embodying the

results of actual experiments made on material manufactured for this particular work, are a real addition to the amount of knowledge already possessed on this interresting subject. The tables illustrating the comparative strength of tension bars enlarged at the end, in two different ways, by the insertion of a wedge and by upsetting, are specially instructive. Another table of no small value is that given in Appendix No. 4, in which the weights of several varieties of iron bridges are compared; the principal portion of this table is compiled from the designs which were submitted by the contractors who made bids for the superstructure of the Quincy Railroad Bridge, but the table also embraces a number of the more noted bridges which have been constructed abroad.

Appendix No. 3, which contains the specifications of stone, timber, and iron work, is very valuable for reference, and contains much matter in a small compass. The use of beton for the backing of ashlar work, which was adopted almost universally on the Quincy bridge, is a practice somewhat novel in America, but one which deserves a thorough examination; whenever used it has been favorably reported upon, and with the improvements which have recently been introduced abroad in the manufacture of beton, it is undoubtedly capable of a wide extension in use.

The last chapter of the volume is a succinct statement of the cost of the work. Like all collections of figures, it is dry to the general reader; but as it embraces many matters of detail, it can be easily made of service in preparing estimates of similar works, and is by no means the least valuable part of the book.

There are, it must be admitted, some few parts of this book which are not above criticism. In the tables giving the strains in the superstructure, the draw when closed is treated as if formed of two disconnected girders of 180 ft. each, a supposition which must evidently give results materially different from the strains which actually occur under these circumstances. It is true that when the deflections have been taken out at the ends by the lifting gear provided for that purpose, the actual strains are so much reduced as to fall within the limits given in the tables of maximum strain (excepting in the central panel ties and posts); but this will hardly justify the computation of strains upon a mistaken hypothesis, still less the publication of such computations. Again, in the case of the fixed spans, the counter-ties are credited with a strain from the centre to the end of the truss; whereas it is well known that only 2 or 3 of the counters on each side of the centre will ever be subject to any strain. Curiosity also raises the question of how the strains on the panel ties of the Bollman truss, which are carefully figured out in pounds, are computed. Though these are undoubtedly errors, they are errors which are not peculiar to this book, and which are really to be ascribed to the superficial method in which these matters have generally been treated by bridge builders, rather than to the fault of the author, who has generally shown an excess of care in his calculations.

It is to be regretted that the style in which the book is published is not worthy of the matter which it contains. This is especially true of the plates, which are comparatively coarse photo-lithographs, and, like some of the ancient philosophers, mask their real merit by a coarse exterior. The Quincy Railroad Bridge is a carefully finished structure, and with all its magnitude presents a graceful and attractive appearance; this volume descriptive of it has been carefully prepared and needs only a corresponding exterior beauty to be a fitting counterpart to the actual work.

Channel Ferry.—Mr. J. S. Mackie thinks he has solved the problem of a rapid and easy ferry from Dover to Calais, by his swift Channel passenger steam-vessel, which will carry a thousand passengers at once, and roll not more than 13 in. in the stormiest sea. He showed at the Royal Society's *conversazione* on the 5th instant, two models, one of which, eight feet in length, steamed merrily up and down a tank provided for the occasion. Two waterways, with three paddle-wheels working in each, extend from bow to stern; and it is asserted that the vessel, when built, will cross the Channel in less than an hour.

East River Bridge.—Borings on the site of the west pier were commenced on the 15th of May.

INFLUENCE OF THE SUEZ CANAL ON TRADE WITH INDIA.*

It seems to me that the subject may be conveniently viewed under two heads, the one showing how, by means of the canal, India is brought closer to Europe for purposes of commerce, and how new fields of commercial enterprise may be opened up, which hitherto have been inaccessible except at great cost and lengthened periods of transit, economizing in the same process that most valuable of all commodities, time; and, under the second head, it may be shown that increased communication and rapidity of transit will make and supply increasing wants, and in so doing, develop the resources of India, and distribute them for the benefit of the world at large.

I propose to confine my own remarks to the first of these two branches of the subject, leaving other gentlemen, better qualified than myself, to deal with the second.

It will be necessary, in the first place, to see what distances at the present time have to be traversed between ports of British India and ports of Europe, *via* the Cape of Good Hope, and then to compare them with those between the same ports *via* the Suez Canal, ascertaining at the same time how, if enhanced freights are required for steamers by the latter route, they will contrast with the loss of time by sailing vessels on the former.

Assuming, then, as a fact, that the Suez Canal is so far successful that there are now no obstacles to its being freely traversed by steamships, as ordinarily used for commercial purposes—a fact which, if a matter of doubt at its first opening, is now unquestionable from the use that has already been made of it, and the removal of the only serious difficulties to its navigation—one or two general propositions may be laid down for convenience in argument, and for the purpose of saving further reference, viz.:—That steamers may be considered to average a rate of eight to nine knots per hour, and sailing ships five to six knots per hour, and that uncertainty as to time of delivery can be brought to a certainty by steamers only. In speaking of sailing vessels, I assume that they will practically be the only carriers on the Cape route, and have purposely excluded steamers from consideration as regards that line of traffic, because at the present time it is well known that the expense of the fuel for the long voyage is so great, and the time saved so trifling in comparison, that steamers are not an ordinary means of transit. As science advances in the economizing of fuel, there may be an improvement in this direction, but it will require vessels of great power and speed to shorten the mileage now entailed by the prevalent winds within the tropical belt. With these general propositions and my own experience to guide me, I have drawn out a table which shows, with sufficient accuracy for the present purpose, the comparative mileage transit between port and port actually traversed, and the time occupied in making the passage. They are, taking the Land's End of Cornwall as a common point of departure from England, or ports in Europe north of Brest, as follows:

Port.	*Via* the Cape.	*Via* the Suez Canal.	Difference.
	Miles.	Miles.	Miles.
Bombay.....	11,500	6,300	5,200
Kurrachee.....	11,200	6,100	5,100
Calcutta.....	13,000	8,000	5,000
Singapore.....	13,000	8,200	4,800

In point of fact, therefore, to a steamer averaging 8 knots, and to a sailing vessel averaging 5½, which, considering the area they have to traverse at times to make their course and distance good, is the outside that can be allowed to them in the most favorable seasons, the time occupied will be as follows, omitting fractions of days:

* From a paper by Sir Frederick Arrow, published in the "Artizan."

Port.	Steamer in days.	Sailing Ship in days.	Difference in favor of Steamer.
Bombay.....	33 + 3 coaling = 36	87	51
Kurrachee.....	32 + 3 " = 35	85	50
Calcutta.....	42 + 5 " = 47	99	52
Singapore.....	43 + 5 " = 48	51	51

Having thus disposed of the question of mileage and time, it remains to be seen whether these advantages compensate for the increased cost of navigating a steamer. This is not very easy to arrive at, for there are at present so many varieties of engines and such differences in the cost of the motive power, the principal element, that any sort of average would be fallacious. I propose, however, instead, to take as an example, a class of vessel now being built, combining carrying capacity and economy of fuel and wages, which will, I think, be a type for this trade, and to compare it with an average sailing vessel of the class mostly used in the trade, founded upon the experience of actual voyages made, the two vessels being of about equal carrying capacity, say about 1,200 tons burthen each. I find that, as regards times of transit of the latter, they nearly coincide with the calculations I have above made, but independently of them. The steamship will carry, in addition to her stores and coal for 28 days, 900 tons of goods; the sailing vessel, 1,200 tons.

The portage bills for both vessels are nearly the same; the canal rate on the steamer is about 6s. per ton on 900 tons of freight—say £270. The cost of coal may be averaged at 35s. at all ports, and the amount consumed on a passage to Calcutta would be a little over 400 tons. Taking, therefore, as an example, the voyage in which the sailing vessel would do best, viz., from Calcutta to London, the following would be an approximation to the result:—The steamer would do the distance in 47 days, her expenses being—coal, £700; wages, £300; canal dues, £270; total, £1,270; and she would deliver 900 tons of goods, say at £3, £2,700; leaving net earnings, £1,430. The sailing ship would deliver 1,200 tons in 99 days; the wages, steam hire, etc., would come to at least £700, and crediting her with the same rate of freight, would net £2,900, or as near as possible double that of the steamer, and occupying more than double the time. As the steamer, therefore, will make two voyages to the sailing ship's one, it seems to me the case is made out that the canal can compete successfully with the Cape route. I have not attempted to go into minute calculations as to insurance, repairs to vessels, original cost, etc., but I think I have gone far enough to prove that steam can compete, *via* the canal, with sailing vessels by the Cape. I have purposely put the case favorably to the latter. I have taken the freight at equal rates. I have not touched on a round voyage, when not only would the outward freights be more against the sailing ships, and the cost of coal more in favor of the steamers, but the loss of time would be still greater, and I have taken the port of Calcutta as furthest to the eastward, and therefore more favorable to the sailing vessel. On the west side of India, the results would be proportionately more in favor of the steamer, as I have stated in a little pamphlet, lately published, a copy of which I had the honor to send to this Society.

Assuming it as proved that the Suez Canal can compete with the Cape route, let us see what further advantages it presents. I think we may say it will probably open a considerable trade between India and Italy, the Morea, Islands of the Grecian Archipelago, and the countries bordering the Mediterranean, including Spain, whose industry, although still undeveloped, is represented by many cotton and other factories at Barcelona and elsewhere on its Mediterranean shore. It will probably create a direct trade between the coasts of the Black Sea and India, by placing the latter in direct communication with Russia and her teeming population. By the Cape route all these places are excluded from direct communication, except perhaps those immediately contiguous to the Straits of Gibraltar, and we may consider Marseilles as the point at which supply comes no longer from the westward.

On a previous occasion, a remark was made that there was not much credit due in making this canal. It was said that it was simply supplying a want for which the time had come. It struck me then that no greater compliment could be paid to the eminent man by whose perseverance and energy the undertaking has been carried out, and I accept it as conveying what, in my opinion, is the highest praise that can be bestowed on it. I believe it is a real want, and that its supply is another link in the chain which binds mankind together, and in which each successive link of discovery of nature or science is forged with stronger power. It is within my memory, as of many here, when the first steamboats were put on the waters, when the iron horse first traversed the rail; and we have all seen how the necessities of those great advances in communication required still further development. Thought was required to travel faster than locomotion by the very advantages the latter gave, and then came that wonderful discovery of the electric telegraph, now being carried to such perfection that, ere another two years have passed away, we may feel the furthest ends of the world to be as practically familiar to us as are now Paris or Vienna; but this again creates fresh wants, requires greater rapidity, regularity, etc., and in obedience to this law, the Suez Canal has been formed.

I will not pursue the theme—it is as diversified as it seems to be endless; but I claim for the Suez Canal and the enterprise of its great and large-minded author a fair and full recognition. At the present moment its influence is being felt in a decrease of the cost of fuel east of the Isthmus, which certainly will have great effect on the cost of carriage, and therefore in the cost of laying down produce and goods. The existence of this route, it appears to me, will stimulate production, not only in India, but in the various countries which it brings into the family of commercial relations, and seems to me the natural channel for the produce of India. If so, it must increase that produce, and must benefit India itself. England wants cotton, so do other countries—a want likely to increase—and at the moment that a network of railways has connected the great port of Western India with the cotton districts, comes into being that channel which will most quickly and cheaply take the staple to the place where it is needed. From the northwest by the Indus and the railway system of the Punjaub, another great feeder to it opens, while the rail from Madras to Baypore on the west coast gives a speedier and cheaper transit from the east coast of India, *via* the Canal, than by the Cape. These are considerations, however, which come more under the second head of this subject, and I do not propose to enlarge upon them, as they will be, I am sure, done justice to by those better able to handle them than myself.

Hydraulic Propeller.—Mr. Henwood believes it possible that the hydraulic propeller may prove more suitable for ships of war than the screw, that liquid fuel may supersede coal for generating steam, and that an efficient plan for sheathing the bottoms of our iron ships with zinc may be discovered. Considering that these at present unsolved problems may, and undoubtedly will, cause another reconstruction of our navy, involving an expenditure of £12,000,000 or more, Mr. Henwood believes it most unwise to lay down at the present time iron-clads which will take 2 or 3 years to complete, at a cost of £30,000 apiece.

National Lifeboat Association.—The National Lifeboat Association state that since their last report 21 new lifeboats have been, or are about to be, placed on the coasts of the United Kingdom and the Channel Islands. Carriages and boat-houses have been likewise provided for nearly all the boats. The institution has now 220 lifeboats on the coasts of Great Britain and Ireland and the Channel Islands. During the past year these boats have rescued no less than 871 persons from various wrecks; nearly the whole of whom were saved under circumstances which would have precluded their being saved by any ordinary boat.

The Elevated Railway in Greenwich street broke down recently under the tests applied by the engineer. The directors promise an early opening to the public.

LOAD-DRAUGHT OF MERCHANT SHIPS.*

From "The Mechanics' Magazine."

The proper draught for a merchant vessel, said the author, is not a question to be determined in the first place by science, but by experience. Science may lend her aid, in generalizing the results of experience, but must unhesitatingly accept the dicta of those whose position and long practice make them the real arbiters of the question. The naval architect and ship-builder must bow, like others, to the decision of these experts. The load-draught cannot be arbitrarily fixed by the naval architect. Lloyd's rules, 3 in. to the ft. depth of hold, or the scale of the Liverpool underwriters, may be quoted; but these blind no one. Lloyd's rule was a suggestion only, and it was made when iron ships were just being talked of, and when few ships, except East India men, exceeded 700 or 800 tons, and it has never been recognized by Lloyd's Committee, except as an approximate guide for the loading of certain classes of vessels. The Liverpool scale is only intended for first-class vessels, and is subject in all cases to the judgment of the surveyor, who is influenced by the age and class of the vessel, its general proportions, the intended voyage, the nature of the cargo, and other circumstances, favorable or otherwise. The experts who practically rule in these matters are certain surveyors more or less intimately connected with the underwriting bodies, and who, if not practically appointed by shipowners, have secured their confidence. Their great experience enables them to judge very closely as to the draught of water at which a ship begins to damage her cargo or become otherwise unsafe. Wooden vessels are now passing away and iron sailing ships are being largely superseded by steamers. Iron sailing vessels will in future be chiefly employed in long voyages, and new ones will probably be of large size. As regards iron vessels, therefore, considerations depending on their age, the nature of the voyage, the season of the year, as affecting their load-draught, may be omitted nearly altogether. Considerations arising from the kind of cargo may also be omitted, as it is generally acknowledged that, with proper care, and by incurring the expense necessary for making good stowage, any proportion of dead weight may be safely carried. There remain only those conditions which relate to form and proportion, and these, I submit, are sufficiently represented by adopting the customs' measurements and registered tonnage. The suggestion that $\frac{3}{10}$ of the whole displacement is a proper proportion for buoyancy was made years since by Mr. J. Jordan. The author then proceeded to refer to various tables bearing on the subject of his paper; and alluding to the requirement of more free side for large wooden ships than for small ones, he said that the reasons assigned for it were not applicable to iron ships. Large iron ships can be as strongly built as small ones. There can be little objection to the $\frac{3}{10}$ displacement scale for ascertaining when a sufficient quantity of cargo has been placed on board a vessel. But it makes no allowance for extreme length, or for the length and character of the waves which she may encounter. The surveyors state the extreme length in proportion to a vessel's other dimensions, must be considered; but, so far as I am aware, they have not defined to what extent. Like the surveyors, I have not come to any definite opinion on this subject, but wait for better instructions. Like other scales which point out, with more or less exactness, what is the proper load-draught for a vessel, they leave us in ignorance as to what amount of departure from it will render a vessel relatively unsafe or practically unseaworthy. After some observations as to the desirableness of some mode of ascertaining the point at which a ship becomes dangerously laden, the author concluded by the following practical suggestion: Let a round spot 9 in. in diameter be conspicuously painted on every vessel over 300 tons register on each side, midships, at a point through which a horizontal plane would pass which would cut off the upper $\frac{1}{4}$ of the vessel's registered tonnage when she is on an even beam. This would be useful in indicating pretty accurately when $\frac{3}{10}$ of the whole vessel are out of the water.

* Read before the Institution of Naval Architects.

In vessels about 500 tons this mark should be fully its own diameter above water. In vessels of 750 tons it would be 1½ its own diameter above water. In vessels of 1,500 tons it would be 2 diameters above water, in larger ships 2½ diameters. Here no kind of instrument would be required to make the observation. If the spot were very near the surface of the water the ship would certainly be very fully laden, if it touched the water she would be very deeply laden, if immersed or out of sight she would be dangerousiy laden. This would not hurt the ship-owner in any way. The proposed mark would indicate a fact, not an opinion.

A VALUABLE EXPERIMENT.

From "The Engineer."

A paper read last February before the Institution of Engineers in Scotland, by Mr. Peter Carmichael, constitutes so useful a contribution to the literature of steam boilers, that it deserves all the publicity we can give it. Two cylindrical double-flued, or Manchester boilers, made steam at Dens Works, Dundee, for 19 years. These boilers were precisely alike, and of the following dimensions: Length, 25 ft.; diameter, 7 ft.; diameter of furnace end of flues, 2 ft. 9 in.; diameter of back end of flues, 2 ft. 4½ in. The shell was made of ⅜ in. "Glasgow best" iron, the flues of "Glasgow best scrap," also ⅜ inch thick, the end plates were $\frac{7}{16}$ in thick. In June, 1867, certain repairs had to be effected in these boilers, and Mr. Carmichael found that the plates had become very brittle. The boilers were made by Messrs. Carmichael and Company, Ward Foundry, Dundee, and to them Mr. Peter Carmichael wrote. He received a reply to the effect that from experience the firm found that all qualities of iron get hard and brittle after the boilers have been at work more than a dozen years, more especially where exposed to the action of the fire; and that in the furnaces, even Lowmoor or Bowling iron becomes as brittle as common iron in that time, and great care has to be taken in making repairs to prevent the plates from cracking. For this reason they thought 16 or 17 years a long enough period for a boiler to be in use, at a pressure of 40 lbs. to 45 lbs. If used for a longer time the pressure ought to be lowered.

The boilers were kept in work until the beginning of November, 1869, when it was resolved to take out one known as "No. 9," and to test it to destruction by water pressure. The following are the particulars of the test as given by Mr. Carmichael. We may premise that the makers of the boiler, being consulted on the subject, reported thus:

"In the case of the above boilers the pressure has never been so great as 60 lbs., and as our boiler-maker reports that they are not wasted, have always been kept in good repair, and have stood the water test periodically up to 60 lbs. pressure, we would not apprehend any danger from working them a year or two longer. The fact of the iron getting hard and brittle after being in use for a length of time has often been pointed out to us by our boiler-maker of late; and, in consequence, we generally recommend that, in cases of high pressure boilers, the pressure be lowered, or new boilers introduced, after they have been working from 16 to 17 years."

Before testing, all the brick flues were taken down, so that easy access could be got to all parts of the boiler, but it was left sitting on its natural seat. The boiler was then filled with water at about 120 deg. temperature, and a hydraulic pump was then attached. To check off the pressure no fewer than five pressures gauges were put on, four of which nearly indicated the same pressure and tallied with the safety-valve. At 80 lbs. pressure per sq. in. an examination was made, and all appeared to be right; but as soon as the pump was started again the joint of the safety-valve was blown out, and this stopped proceedings for a time. After this joint had been tightened the pressure was again brought up, and at 85 lbs. the joint of the feed pipe at the front end of the boiler began to leak, owing to the bulging out of the end. At 100 lbs. a number of the longitudinal seams of the shell began to "weep" badly. The pressure was then removed, and the ends gauged above and below the flues; and, on the pressure being again put on, the following was the

result: Front end, below flues, bulged out in centre, $\frac{3}{16}$ in. at 35 lbs. pressure; do., do., do., $\frac{6}{16}$ in. at 100 lbs. pressure; front end, above flues, bulged out in centre, $\frac{4}{32}$ in. at 35 lbs. pressure; do., do., do., $\frac{7}{32}$ in. at 100 lbs. pressure; back end, below flues, bulged out in centre, $\frac{4}{32}$ in. at 35 lbs. pressure; do., do., do., $\frac{8}{32}$ in. at 100 lbs. pressure; back end, above flues, bulged out in centre, $\frac{4}{32}$ in. at 35 lbs. pressure; do., do., do., $\frac{8}{32}$ in. at 100 lbs. pressure. The pressure was then brought up to 105 lbs., when the ring seam at the back of the taper of the left-hand flue began to crack, and the pump became unable to keep up the pressure, owing to the great leakage. This joint or seam, when gauged, before testing, measured 2 ft. $3\frac{3}{4}$ in. horizontally by 2 ft. 5 in. vertically; and it gave way by crushing inwards on the flat or horizontal side, and remained flattened after the pressure was removed.

This boiler was then removed and sent to the foundry for breaking up; Mr. Carmichael proceeded to clear away the brick flues from the sister boiler. On the 15th December, 1869, it was tested in the same way, having been in use for rather more than 19 years. The flues were gauged, and were found, with one exception, similar to those of No. 9. The exceptional one being $1\frac{1}{2}$ in. oval, it was attempted to support this flat part by fixing a batten in the line of the shortest axis of the ellipse; but this was not found to be of any use, as the plate bulged out below one end of the batten and above the other, and loosened it when the strain came on. The pressure was noted as before: At 60 lbs. pressure the feed-pipe began to leak, the end bulging out $\frac{1}{16}$ in., as before. At 80 lbs. the feed valve-joint leaked very much, and the longitudinal seams of the shell began to "weep." At 90 lbs. the south, or right-hand flue began to crack, as if giving way. At 95 lbs. one of the joints of the shell, first rings, on the crown of the boiler, commenced to spout water, and the pressure could not be kept up, the leakage being equal to the supply of the force pump. The joints of the feed-valve were then tightened, and also some parts of the shell caulked, the right-hand flue being found to be very much flattened. The pressure was again put on, but it could not be got higher than 80 lbs., as the flue had given way so much as to allow the water to escape as fast as it was forced in; so that the highest pressure attained was 95 lbs., and this pressure had so injured the joints and flattened the flues as to render further experiment impossible. When taken off their seats, neither of the boilers was found to be corroded, either on the shells or flues; in most places the corners were as sharp, and the skin of the plates as fresh, as when they left the hands of the boiler-maker 19 years ago.

These two experiments are eminently instructive, throwing, as they do, considerable light on the fact that old boilers, apparently strong and sound, give way sometimes without the slightest previous warning, simply because of the deterioration of the iron by use; a deterioration, we may add, the occurrence of which has been flatly denied by many engineers in the face of a host of facts to the contrary. It also shows that it is not prudent to accept the rules commonly laid down as to the strength of boilers without qualification. According to Fairbairn's rules, the bursting pressure of these boilers was about 300 lbs. on the sq. in., yet they failed with one-third of this pressure. Whether they would or would not have withstood the pressure when new, it is impossible to say; but judging by the fact that the only deterioration they manifested was in the quality, not in the thickness, of the plates, the chances are that they would not, as brittleness—in other words, absence of powers of extension—is by no means incompatible with a high tensile strength if the strain be gradually applied. At all events we have it demonstrated that boilers should not be worked more than 15 or 16 years under any circumstances. Mr. Carmichael read a part of a report from the boiler-makers who broke the boilers up. So brittle were they that it was found almost impossible to get some sound test strips, which were sent to Mr. Kirkaldy. The rivet heads on the outside of the boiler flew off when the inside heads were struck by the hammer and set, so that the material of the rivets had deteriorated as much as the plates. As to the original strength of the plates, Mr. Kirkaldy, in "Experiments on Wrought Iron and Steel," gives at p. 150, the tensile breaking strength per sq. in. of original section as follows: Glasgow best boiler plate, drawn in direction of

fibre, 24.04 tons; do. across, 21.8 tons; Glasgow best scrap plate, 22.7 tons; mean, 22.92 tons. The test strips cut from Mr. Carmichael's boilers gave the following results: Shell plates, direction of fibre, 19.7 tons; do. across, 19.2 tons; mean, 19.45 tons. Furnace plates, direction of fibre, 17.1 tons; do. across, 15.3 tons; mean, 16.2 tons. It will thus be seen that, according to this report of testing, compared with Mr. Kirkaldy's table, while the shell plates have deteriorated or weakened from 22.92 tons to 19.45 tons, the furnace plates are decreased in strength from 22.7 tons to 16.2 tons. It must not be forgotten, however, that nearly all Scotch iron is cold short.

We trust that many other firms will follow the excellent example set by Mr. Carmichael, and, when possible, test their rejected boilers to destruction as he has done. Even if they will not incur this expense, we invite them to send test strips from the broken-up boilers to Mr. Kirkaldy. A score of experiments of this kind would supply an enormous amount of information of the utmost value to engineers. Mr. Peter Carmichael deserves the thanks of the profession. He has ours.

ON THE DRESSING OF LEAD ORES.

From "The Artizan."

In a paper lately read before the Institution of Civil Engineers, the author, Mr. T. Sopwith, Jr., described some works he had recently established in Spain.

By dressing was to be understood the art of obtaining from the raw material extracted from the mine, called bouse, or mine stuff, the pure ore it contained, to the rejection of the impurities with which it was associated. Bouse might be said to yield, in an ordinary way, from 5 per cent. to 25 per cent. of galena, which when pure had a specific gravity of 7.75, and produced 86 per cent. of metallic lead. The lead ores of commerce were usually dressed to a tenor of from 74 per cent. to 78 per cent., though argentiferous ores were frequently delivered with a lower percentage. All galena was mixed with silver; but the term argentiferous was only applied to that in which there was upwards of 12 oz. of silver per ton. In dressing, the principle applied was that of separating the lead ores by means of their readier gravitation. This operation was easy or difficult according as the accompanying impurities were of greater or less specific gravity.

At the works referred to, about 350 tons of lead ore were prepared per month. There were two dressing floors, the higher and the lower. On the former, manual labor was principally employed. On the lower floor the stuff was treated which required to be passed through the crushing mill; and it was more particularly this machinery and method that it was the purpose of this paper to describe. On the higher floors from 200 to 220 tons per month were prepared, or two-thirds of the entire quantity. Two systems of paying the miners were adopted in mineral mines: one, by "tribute" or "bingtale," where the men were paid in proportion to the amount of clean ore the mine stuff excavated by them produced; the other, "tutwork" or "fathomtale," where they were paid by measurement. The adoption of the former system introduced complication, and more expense in the dressing operations than the latter.

The author, in describing the various machines, and the quantities of work they could deal with, fixed as a standard the richness of mine stuff treated at about 12 per cent. (by weight), equal to work which would be known in the North of England as producing 2½ bings per shift.*

The washing operations commenced by turning a stream of water into the "teams" containing the "bouse," which was raked out by a man on to a grate and there hand-picked. The author used two grates; the higher one with spaces of 1 in., and the lower one of ½ in., in preference to the one grate with spaces ⅝ in. wide, as usually employed. The stuff passed through the second grate into a stirring trunk, where a partial separation of the coarser particles from sludge and slime

* A bing is 8 cwt. A shift is 8 wagons, carrying about one ton each.

was affected. The coarser particles were of a size convenient for hotching, and the common hotching tub could treat from 8 tons to 15 tons of stuff per day. Between the waste, which was wheeled away, and the pure ore, there was an intermediate layer of what was called "chatts," consisting of particles mixed with ore which could not be separated without further subdivision. This was effected by means of a crushing mill. In England from 25 tons to 30 tons was a fair day's work to pass over one grate. The author found, by the use of two grates, that 40 tons could be passed, without any increase of labor, at a cost of about 2s. 6d. per ton of clean ore produced.

The ore which passed through the coarse wire bottom of the hotching sieve, accumulated at the bottom of the tub, and was called "smiddum." This was rendered fit for market by further preparation in a plain buddle. The sludge deposited in the trunks attached to each grate was prepared in a round buddle. A separation having first been made of hard lumps, small stones or chips of wood, etc., the sludge was delivered at the centre of the buddle accompanied with water. The bottom being inclined outwards about 1 in 10, the particles were carried by the water in that direction; the heaviest and richest being deposited nearest the centre. The buddle described was larger in diameter, and treated nearly four times more stuff, than that usually employed. The water, on leaving the sludge trunk carried with it a certain amount of slime, which was deposited in pits, and was subsequently treated in a machine called a Brunton's cloth, the action of which was described, as also of the dolly tub, by which the slimes, after being concentrated in the Brunton's machine to about 45 per cent., were further enriched to about 70 per cent., and so delivered for sale. The crushing mill in common use in England was described, and the inconvenience attached to it, as compared with the simpler form used in Germany, was pointed out. In the apparatus that had been referred to, it was probable that about 80 per cent. of the lead ore produced in England was prepared.

On the lower or crushing mill floors, which the author had erected, some attempt had been made to secure continuity of action, by the use of self-acting machinery, wherever it was possible; though from the circumstance of Spanish laborers being employed, who were totally unaccustomed to the use of machinery, it was necessary that the machines should be of the simplest kind. The stuff which required crushing was conveyed in wagons to the lower floors, being first broken to a size which would pass through a 5-inch ring. This was effected by manual labor, in preference to a stone-breaking machine, as the former allowed of a separation of a small quantity of pure ore, and of a large quantity of waste, which would afford unnecessary work for the crushing mill. The stuff, after being emptied from the wagons in the hopper of the crushing mill, was passed through the rollers, and, when crushed, was elevated by a Jacob's Ladder, and delivered into a classifying trommel, composed of two shells, an outer one of perforated iron plates with holes of 1½ millimetres in diameter, and an inner one with holes of 10 millimetres in diameter. The crushed material was delivered in the inside of the trommel at one end, and passed onwards, the trommel being inclined. All the sludge and slime were got rid of through the outer shell, the inner shell retaining and delivering apart any particles over 10 millimetres in diameter. These were returned to the crushing mill, to be again passed through the rollers, and the particles, ranging in size between 1½ millimetres and 10 millimetres, were delivered at the further end of the trommel, and passed on to a second, or sizing trommel, composed of one shell only, and were then subdivided into four sizes, viz., 2½, 5, 7½, and 10 millimetres, each size being treated in a separate hotching tub. For the operation of hotching, the convenience of having all the particles treated of one, or nearly of one, size, was obvious; and in some cases of refractory ores it was a necessity. The hotching machines employed were entirely self-acting, and continuous in action; a fast and a loose pulley being attached to each machine. Contrary to the form adopted in England, the sieve was stationary, the water being put in motion by means of a loosely fitting piston. The stuff was delivered into a small hopper, and travelled the length of the sieve, a distance of 28 in., by which time a perfect separation was effected. It had been found advantageous to increase the length of the

stroke, and the number of strokes per minute, for the larger sizes. By an ingenious movement, a quick down stroke and a slow return stroke had been given to the piston. The crushing mill was more compact than the form used in England, the rollers being kept in contact by the compression of india-rubber buffers, in place of a long lever, with a heavy weight attached. The sludge, which passed through the holes of 1½ millimetres in diameter, in the first, or classifying trommel, was delivered into a separator—an iron cylinder about 2½ ft. high—where it met a stream of water of sufficient strength to carry the smallest and lightest particles upwards, and deliver them into a launder, whence they were conveyed, by the water, to the sludge trunks and slime pits, and were subsequently treated in round buddles and in Brunton's cloth. The coarser particles were prepared by manual labor, in a common trunk or tie.

The amount of work crushed and prepared on the lower floors was about 55 tons per day of 10 hours. The actual cost in Spain was 21s. 2d., but the equivalent of labor would be performed in English mining districts for 13s., the latter sum being at the rate of 2.83 pence per ton of raw material treated, or 2s. per ton of clean ore produced. If, however, self-feeding apparatus was introduced to supply the hotching machines, which could easily be done, the latter cost might be reduced to 2.07d. and 1s. 5¾d. respectively. The cost of preparing similar work in England, with machine crushers and machine hotchers, was, the author believed, about 2s. 6d. per ton of clean ore. The whole of this machinery was driven by a 10 H.P. portable engine, supplied by Messrs. Ransomes, Sims & Head. The cost of erection of the crushing mill floors complete, including the engine, was about £1,500. The same arrangement in England would have cost about £1,200. Most of the machinery was supplied by Messrs. Sievers & Co., of Kalk, near Cologne. No separate crushing mill for the preparation of "chatts" had been erected, as when the "chatts" had been allowed to accumulate, the present machinery could be adapted for their treatment in an hour or two, advantage being taken of a time when new rollers had been put in.

The author observed that whereas, in England, the machinery employed in dressing operations was for the most part made at the mine with the ordinary staff, in Germany there were manufactories giving employment to 400 hands, dedicated almost exclusively to the construction of dressing machinery; and it was not surprising to find, in the machines issued from them, better proportions, greater elegance, and more efficiency and durability than those used in the mines in this country.

The machinery described in this paper had been in use for two years, and having given good results in Spain, no difficulty need be feared in its application elsewhere.

BRITISH INDIAN SUB-MARINE CABLE.

From "The Mechanics' Magazine."

When the enormous length of cable in connection with this enterprise is considered, it is a matter of great congratulation to all that the entire amount should have been submerged between Bombay and Suez without any serious hitch. Up to the present no expedition has been attended with such unqualified success, and in all probability it will be found to materially improve the prospects of submarine telegraphy. Of the advanced stage of confidence in deep-sea cable laying, no greater proof can be given than the small amount of space allotted to the progress of this work in the daily press; beyond the usual telegrams announcing the gradual progress of the work, little or no mention has been made. This is a matter of some little surprise, for the present cable exceeds in length that of any cable previously laid.

The entire amount of cable was completed on December 11 last, and the last section shipped some time later, but this would at first seem to show some delay in the prosecution of the work; that, however, was not the case, for the entire work has been completed within the time specified by contract. The first great object was to get the Great Eastern away in

time; this was successfully accomplished, and the remainder of the cable sent away with the appointed ships.

The following vessels were engaged in the work: Great Eastern, Hibernia, Chiltern, William Cory, and Hawk, and the stowage on board of the different types was as follows:

GREAT EASTERN.

	knots.
Type D, Bombay shore end	10
" B, intermediate	70
" E, second ditto	86
" C, main cable	1,874
" D, Aden shore end	10
Bombay-Aden section, total	2,050
Suez-Aden section—	
Type B, intermediate	325
	2,375

CHILTERN.

Type D, Aden shore end, Suez-Aden section	10
" A, main cable	250
	260

HIBERNIA.

Type A, main cable, Suez-Aden section	613

WILLIAM CORY.

Type A, main cable, Suez-Aden section	312

HAWK.

Type D, Suez shore end, Suez-Aden section	10
Total	3,600

The Great Eastern, accompanied by the Chiltern, made a successful passage round to Bombay; the Hibernia, with her section, was timed to arrive at Aden on the completion of the Bombay-Aden section; the William Cory and Hawk departed still later, and going to Suez by the Lessep's Canal, were to arrive there and begin paying out, so as to meet the expedition in the Red Sea, near the Dædalus Light. It will be seen how excellent were these arrangements and how well carried out.

The coaling and other necessary arrangements having been completed at Bombay, the Chiltern first laid the shore end on February 7, and buoyed it. On the 14th the two vessels proceeded together to the buoy on the end. The Chiltern lifted the end, and having received the end of the cable from the Great Eastern, the splice was made and slipped. Paying out from the Great Eastern commenced at once, and continued throughout the night; and at noon on the 15th, 98.5 miles were payed out, with a percentage of slack of 2.7; and at 8.38 P. M., the splice on to the deep-sea cable passed over the stern. On the 16th the depth had increased to 1,876 fathoms; and at noon of the 17th, to 2,170 fathoms—359.7 knots being payed out with 9.6 per cent. slack, and at an average speed of about 5.4 knots per hour.

The weather throughout was fine, and paying out continued uninterruptedly, no accident or mishap occurring, the only stoppages taking place when the shift of tank became necessary; these were accomplished quietly and without difficulty. On the 26th the Chiltern went forward to mark the point for terminating the deep-sea cable and the commencement of the intermediate type. On the Great Eastern joining her, the cable was cut and the intermediate spliced on, and about 20 miles of intermediate being payed out, the end was buoyed on the morning of the 27th, there being too much wind and sea for laying the shore end, up to this point a total length of 1,808 knots having been payed out. Some slight delay was occasioned through bad weather, but on March 2 the shore end was laid and the final splice made, the tests throughout continuing perfect. The exact length payed out being 1,818.16 knots, leaving a surplus amount of cable of 231.84 knots, showing that more than ample provisions had been made, not alone for slack, but in case any accident should happen.

The day following the completion of the Bombay and Aden section, the Hibernia made her appearance at Aden and preparations were at once made for immediately laying the Red Sea section. The shore end from Aden was laid by the Chiltern, and on March 6 the expedition started. The end from the Great Eastern was taken on board the Chiltern, and the splice between it and the shore end was made and paying out commenced next evening. All went on satisfactorily, and at noon next day, 124 miles had been payed out with only about 2 per cent. slack, owing to the shallowness of the water. On the 8th, at midnight, the Great Eastern's section of 325 miles was completed and buoyed, and on the following morning the Hibernia lifted the end and spliced it on to her cable, and immediately afterwards commenced paying out. On the 13th the Hibernia had completed her task and paying out was started from the Chiltern; it was originally intended that the Chiltern should complete the work, it having been

arranged that the Hawk should lay the shore end, and the William Cory pay her cable out towards the rendezvous near the Dædalus, but some delay having occurred, the Chiltern arrived there first; it was consequently determined to pay out all her cable, which was accordingly done, and the end buoyed on the 15th March. The Chiltern remained by her buoy, which was let go in 388 fathoms and about 100 miles on the Suez side of the Dædalus, while the Hibernia went in search of the paying out vessels from Suez. These were come in sight of and paying out was going on successfully, and the William Cory arrived off the buoy, but owing to unfavorable weather the final splice was not made until March 22d.

In contemplating the present work, there are several points which immediately claim attention. The first of these is undoubtedly the wonderful success attending the work, especially as regards the entire absence of electrical faults. From the commencement of the paying out at Bombay to the completion of the work, the final splice in the Red Sea representing a length of over 3,000 miles of cable, the electrical tests gave the condition of the cable as perfect, and the insulation constantly improving—not a single hitch, not a sign of a fault; the longest length of cable hitherto laid completed without any *contretemps* beyond that due to weather. It is certainly a wonderful success, and the accomplishment of this work must be looked upon with universal gratification.

Hitherto the accidents and faults that have occurred have been most beneficial; they have proved beyond doubt that when they do occur, there is a certainty in repairing them even in deep seas; they have consequently given great confidence in the facility of laying and repairing deep-sea cables, but there is certainly more satisfaction in having a long cable laid without the occasion of putting these proofs to the test.

It is not long since we chronicled the successful completion of the French Atlantic cable. The present cable exceeded only by a few miles the length of that cable, and as regards the deep-sea portion, was somewhat less. The present cable has been completed without a hitch or fault. The French Atlantic cable had several faults, all occurring in the deep-sea cable. The electrical testing was watched carefully throughout in both cables, and it may be safely asserted that there was not a single electrical fault in either cable before paying out commenced. It may still be asked—why should faults occur in one and none in the other? The structural appearance of the cables may answer this question. We cite the French Atlantic cable, but the older Atlantic cables may do as well. Similar faults made their appearance in them, and which have before now been attributed to maliciousness—a reason we cannot agree with.

The Atlantic type of cable consists of a sheathing of homogeneous iron wires served with strands of hemp. In places this wire is brittle and elastic. It frequently breaks and springs up. What more probable than its piercing the layer of cable above or below it, and penetrating as the cable is payed out—the sudden jerk breaks off a short piece, leaving it sticking in; the bearings it passes over in paying out will complete the mischief, and make a fault while at the same time frequently removing the cause. In almost all the cases that have occurred, the signs have been the same, and the cause has also been seen.

Why should not the same things have occurred with the present cable? The original type is the same as that described, but it is also added to. After the cable had been sheathed with its strands of hemp and steel, it received a thin serving of hemp in an opposite direction, and then passed through a bath of Clark's compound, binding the whole up so firmly that even if a wire did break, it could not possibly escape and do damage. There can be no question that this new form of cable has added most materially to the success of the expedition—a success which, we are glad to observe, reflects the greatest credit upon all the persons engaged, and probably upon none more than upon the organizers of the expedition.

A GREAT discovery has been made in Bengal. Coal has been found at Midnapoor while boring for water for the use of the gaol. It is not impossible that further borings may establish the existence of a coal field beneath the laterite formation, that extends from Ranigunge to Midnapoor.

PROPOSED NEW MODE OF LAYING AND RAISING SUBMARINE TELEGRAPH CABLES.*

Messrs. Sidney E. Morse and G. Livingston Morse, of New York, propose a new method of laying submarine telegraph cables. Submarine telegraph cables have hitherto been laid, as nearly as possible, in one continuous straight line on the bottom of the sea. It is obvious that when a cable has been thus laid, it cannot be raised from the bottom to the surface in the deep sea without breaking it, and then raising successively each of the two parts, and that it cannot be repaired there and relaid without splicing to the two broken ends new cable of a length equal to at least twice the depth of the sea at that point. Messrs. Morse propose to lay the cable on the whole line, in the first instance, in such a way that it can be raised at any time for repair, or for any other purpose, at any assigned station or stations on the line, and then relaid, without breaking it.

In laying a submarine cable entirely across the ocean, Messrs. Morse propose to employ two vessels. The first and larger vessel is to carry the telegraph cable in any required length, either enough for the whole line, or for one or more sections of the line, as may be desired, together with the ordinary apparatus for laying this cable on the bottom of the sea. The second and smaller vessel is to carry, first, a lifting cable, long enough at least to reach the bottom of the sea at the deepest point on the line, and strong enough to support a weight equal to the weight in water of ten miles of the telegraph cable, if the depth of the sea on any part of the line should be as much as two miles, and proportionally stronger if the water should be deeper, this lifting cable having firmly attached to its lower end a strong, heavy iron ring, seven or eight inches or more in diameter; and, secondly, as many properly constructed iron hooks as there are stations on the line, at which provision is to be made for raising the telegraph cable; each hook to be strong enough to support the ten miles or more of telegraph cable; the shank of each hook to be provided at stout and strong as the hook itself, and short intervals with five, six, or more barbs, all pointing downwards, but in various directions, each barb being as the shank terminating in an eye, in which is firmly fastened the end of a galvanized iron wire rope; it may be five or ten miles long, or more, and between one-eighth and one-fourth of an inch in diameter; the strands of this wire rope to be untwisted at suitable intervals to embrace wooden cases in the form of cylinders, about four inches in diameter and of indefinite length, but with tapering, conical ends; the cylindrical part of each wooden case to contain a sufficient number of three-and-a-half inch hollow glass spheres to give the wire rope any required buoyancy at any required intervals.

Thus freighted the two vessels leave a terminus, let us suppose, in France, to proceed along the arc of a great circle, nearly due west, to Newfoundland, a distance of about 2,000 miles, to lay the telegraph cable so that it may be raised at any future time without breaking it, at any one of 19 stations 100 miles apart. The smaller vessel goes ahead on a nearly due west course, and is followed by the larger vessel, from which the telegraph cable is payed out and laid on the bottom of the sea in the usual way. After the smaller vessel has proceeded 100 miles it stops, turns with its bow to the north, and, one of the hooks having been suspended from its stern, with the ring at the end of the lifting cable under one of the barbs on the shank of the hook, waits for the larger vessel, which, as it passes on its westerly course, deposits its cable in the hook and proceeds until the telegraph cable rests again on the bottom, leaving a certain length suspended from the stern of the smaller vessel in the form of two catenarian curves, extending each from the hook to the bottom of the sea, one in an easterly and the other in a westerly direction. If the depth of the sea at that point should be two miles, the speed of the larger vessel in laying the cable could be so regulated that the span between the two points at which the cable would touch the bottom would be eight miles, and in that case the length of cable

* From the Report of Prof. S. F. B. Morse, LL. D., U. S. Commissioner to the Paris Exposition.

included in the two catenarian curves would be about nine miles, and the hook and lifting-cable would support nine miles of telegraph cable at the stern of the smaller vessel. The smaller vessel should then proceed due north for two miles, the lifting-cable meanwhile being allowed to sink and unwind itself from a reel till the whole of the 9 miles of telegraph cable included in the catenarian curves is deposited on the bottom of the sea, as nearly as possible at right angles to the general course of the rest of the line. The lifting-cable should then be made, by the weight of the ring at its end, to detach itself from the hook, and should be drawn up and wound again around its reel in the smaller vessel, which should all the while be continuing on its course due north paying out the iron-wire rope and its inclosed glass-sphere buoys to any desired distance—5 miles, or 10 miles, or more if deemed expedient. The galvanized iron wire rope should be made to terminate in an anchor, and when this anchor is dropped in the sea the rope may be made, by a previous proper disposition of the glass-sphere buoys, to assume any desired form, either that of one long arch or of a succession of arches, rising in the water from the bottom, and as near the bottom or as far from it as may be deemed best. The deposit of the anchor at the end of the galvanized iron wire rope completes the laying of the first section of the line, and the other sections may be laid by repeating the whole process.

The process of raising again to the surface a telegraph cable thus laid is very simple. The latitude and longitude, both of the hook and of the anchor of the wire rope, it should have been remarked, must be accurately taken when they are deposited on the bottom of the sea. When the telegraph cable is to be raised, the smaller vessel, with the lifting cable on board, and a small line, long enough to reach nearly to the bottom of the sea, and having a small hook or grapple of proper construction at its lower end, must be sent to any point of latitude between the latitude of the hook and the latitude of the anchor of the wire rope, and to any meridian within a few miles either east or west of that on which the wire rope is floating below, supported by the encased glass-sphere buoys. With the small line depending from its stern, and extending, with its sinker and hook, nearly to the bottom of the sea, the vessel must then be moved to the east or to the west, till this line shall cross the wire rope and bring it to the surface. When brought to the surface the wire rope must be parted, and the part connected with the anchor temporarily buoyed, while the end of the other part is taken on board the vessel, and, after passing the heavy iron ring of the lifting cable over it, must be held on board until the ring carries the lifting cable down to the bottom, the wire rope guiding it till the ring passes the bars on the shank of the hook which holds the telegraph cable in its grasp. Then, by drawing up the lifting cable, the ring will catch under one of the bars of the hook, and by continuing to draw up, while the smaller vessel is moved 2 miles on a southerly course, or on a course directly opposite to that pursued in laying it, the part of the telegraph cable included originally in the 2 catenarian curves will be raised again to the surface without being broken.

Among the advantages of this mode of laying submarine telegraph cables are the following :

1st. All risk of losing the cable while laying it is avoided. More than 300 miles of the Atlantic telegraph cable of 1857 were finally lost, and more than half of the Atlantic telegraph cable of 1865 was temporarily lost, while the operators were in the act of laying them. These losses would not have occurred if those cables had been laid on the plan here proposed and described. After the parting of the telegraph cable in each case the vessels would have returned to the last raising-station with a lifting-cable, and after raising the telegraph cable from the bottom to the surface at that point the operators would have underrun the raised part till they had come to the broken end, spliced this end to the broken end of the cable in the ship, and proceeded with the work of laying the cable on the bottom.

2d. The risk of losing the cable after it has been laid is divided by the number of raising-stations on the line. The Atlantic telegraph cable of 1858, although successfully laid through its whole line, after a few days of feeble life was totally and finally lost. No one knows where or what was its malady. It may have been

confined to a few feet or to a single point on the line. If it had been laid on the plan herein proposed the place of the fault might soon have been found, the defective part might possibly have been easily removed, and the whole cable restored to permanent and efficient life.

3d. The danger of encountering storms and fogs while laying the cable is avoided. On the plan proposed by Messrs. Morse the cable is laid by sections, and after one section is laid the work may be left for weeks, or for any length of time, and then resumed. The sections may be of such length that a single section can be laid in a single day; and, if the day is judiciously selected, embarrassment from the weather will rarely occur, and, when it does occur, will be of comparatively little importance; but when the cable is laid in one continuous line for 2,000 miles without stopping during the 14 days necessary to lay such a length of line, experience proves that it will be very difficult to avoid serious embarrassment from the weather, even in the most favorable season of the year.

4th. Less length of cable will be required to connect the termini of the line. The length of cable actually used to connect the termini in Ireland and Newfoundland of the Atlantic telegraph cable of 1858 was about 15 per cent. greater than the distance of the two points from each other, measured on the arc of the great circle between them, and, in the cable of 1866, it was about 12 per cent. greater. As this distance in each case is nearly 2,000 miles, it is clear that more than 200 miles of telegraph cable were lost by *unnecessary slack* in attempting to lay the cable across the Atlantic Ocean in one continuous straight line under circumstances uncommonly favorable to economy in the length of cable used; for, in 1866, the weather was so favorable that the ships deviated very little from the true line in their course. The loss of these 200 miles is not merely the loss of the cost of so much cable, but, as more words could be transmitted through the cable in any given time if it were 200 miles shorter, the loss will continue to be felt through the whole life of the cable in the diminution of its capacity to earn income. If the cable had been laid in sections, on the plan proposed by Messrs. Morse, and had been carefully and deliberately laid upon that plan, after soundings at very short intervals along the line with the aid of the bathometer of Messrs. Morse, it could have been made to conform so accurately to the arc of the great circle, and to all the swells and hollows of the bottom of the sea, that the slack might have been almost confined to the stations at which it would have been purposely made, in order to furnish at those stations the necessary means for raising the cable from the bottom to the surface without breaking it. The loss of cable by slack at one of these stations, a loss by which an advantage so desirable is gained, need be only one mile, even when the water is two miles deep, as has been already stated in the account of the Morse process of laying the cable. The loss at 20 stations need, of course, be only 20 miles, or less than $\frac{1}{10}$ part of the length superfluously expended in the method hitherto pursued in laying submarine telegraph cables.

Instead of a lifting-cable, Messrs. Morse propose, in some cases, to send down, to be attached to one of the barbs on the shank of the hook, a buoy, composed of very large hollow glass spheres, inclosed in a tube, the spheres being sufficient in number and buoyancy to support and raise through the water to the surface the whole of that part of the telegraph cable included originally in the catenarian curves. They would put the heavy iron ring over the end of the galvanized iron wire rope held on board of the vessel, and then attach the buoy to the upper side of the ring, while to the lower side they would attach a weight sufficiently heavy to draw the buoy slowly to the bottom. After the ring, guided by the wire rope, has passed the barbs on the shank of the hook at its end (the hook which holds the telegraph cable in its grasp), Messrs. Morse would cause the weight, by a simple device, to detach itself from the ring, and the ring would then be drawn under one of the barbs by the buoy, which, at first very rapidly and afterwards slowly, would rise and draw the telegraph cable to the surface. The weight may be made at little cost by inclosing sand and stone in a bag, or in any suitable cheap material. By this mode of raising the telegraph cable the time and labor of men at a windlass would be dispensed with. The whole work would be performed automatically by the buoy and the weight, and at the expense only of the sand necessary to

sink the buoy from the surface to the bottom, and the cable would be raised far more speedily and satisfactorily by this process than it could be by human labor.

Messrs. Morse also propose to apply their above-described method of laying and raising a long galvanized iron wire rope, suspended by inclosed glass-sphere buoys in the form of an arch or arches near the bottom of the sea, to the end of a submarine telegraph cable laid in one continuous straight line from a station on shore to any assigned point of latitude and longitude in mid-ocean, which point would thus be constituted a telegraph station on the bottom of the sea, accessible for use by the master of any ship who should have a telegraph instrument on board, and a small line long enough to reach the bottom at that point, and who might be acquainted with the latitude and longitude of the mid-ocean terminus of this telegraph cable, and also with the latitude and longitude of the anchor at the outer end of the galvanized iron wire rope. Knowing these points, and allowing the small line with a sinker and hook at its outer end to run out from the stern of his ship till the hook approached the bottom, this ship-master would cross the galvanized iron wire rope with his small line, bring the rope on board, and, without breaking it, underrun it towards the telegraph cable till he came to the light insulated copper wire in which the telegraph cable, for a distance equal to the depth of the sea at that point, should be made to terminate, and then, by connecting this insulated copper wire with his telegraph instrument, he could send and receive communications to and from the shore. After doing this he might drop the iron wire rope and the light insulated copper wire into the sea, and they would automatically assume the position from which they were raised, and be ready to render their services to any other ship-master traversing that part of the ocean.

CYLINDERS FOR HYDRAULIC PRESSES.

From "The Engineer."

The hydraulic, or, as some persons erroneously term it, the hydrostatic press, was patented by Bramah in 1796. It has therefore been known to the world for 74 years, and is now applied in a multitude of operations, which absolutely could not have been performed at all without it. Presses exerting a force of 500 tons, and having ranges of 10 ft., 12 ft.or even 15 ft., and being capable of exerting the force we have named at any part of the stroke, are by no means uncommon. We do not stretch a single point when we say that no arrangement of screws or levers would supply us with a press of equal range, power, and speed. It is not that an arrangement of levers could not be planned quite able to exert the strain of which we speak; but such an arrangement would lack all the characteristics which are essential to a mechanical device intended to serve the purposes of manufacturers. For example, had the work done in raising the tubes of the Britannia Bridge been performed by a simple lever, one arm must have been 448,000 ft. longer than the other, and to enable a pound to raise the load through 100 ft., the pound must have passed through space for a distance of 83,522 miles. In simplicity, in cheapness, and in efficiency, the hydraulic press stands totally without a rival. Whether assuming the form of the gigantic apparatus employed in bending armor plates, or that of a little 30 cwt. jack, it is equally compact, inexpensive, and elegant. It is no matter for wonder that its use is rapidly extending. But it must not be assumed that the hydraulic press, as we have it, is perfect. It is by no means all that can be desired as regards two important features. In the first place, the leather packing of the ram is an endless source of trouble. In the second, it has hitherto been found exceedingly difficult to obtain perfectly sound and trustworthy cylinders, especially of large dimensions. On the subject of packing we shall say nothing now, having already dealt pretty fully with the question in a recent article. We shall confine our remarks for the moment to the questions involved, and the difficulties to be overcome, in the production of cylinders which will prove all that can be desired; and we believe it is in our power

to place many of our readers interested in the subject in possession of facts which they will find novel and valuable.

Obviously, the first thing to be secured in the construction of a hydraulic press is sufficient strength in the cylinder. In practice, hydraulic press cylinders have to withstand working pressures of from 1 to 4 tons per square inch, the latter being more nearly the ordinary pressure than the former. A cylinder 10 ft. long and 12 in. diameter would be called upon under the last-named pressure to withstand a bursting strain, tending to rip it up from end to end, of not less than 5,860 tons. The strength of boilers or other cylindrical vessels of thin iron can be determined by the formula

$$P = \frac{2\,S\,T}{D}$$

where P is the pressure, S the strain allowed to be put on each square inch of the metal, say 8,000 lbs. for ordinary boiler plate; T, the thickness; and D, the diameter of the plate. But this formula will not apply to thick cylinders, and we must then have recourse to that given by Professor Rankine,* which is

$$\frac{R^2 - r^2}{R^2 + r^2} = \frac{p}{f}$$

where R is the external, and r the internal radius of a thick hollow cylinder, the tenacity of whose material is f, and whose bursting pressure is p; consequently,

$$\frac{R}{r} = \sqrt{\left(\frac{f+p}{f-p}\right)}.$$

The formula given by Molesworth is, however, more convenient for general use. It is, let p be the pressure in tons per square inch, D internal diameter of cylinder, x constant for different metals, T, thickness of metal; then

$$T = \frac{\frac{1}{2}\,D\,P}{x - P}.$$

$x = 7$ for cast-iron, 14 for gun metal, and 20 for wrought-iron. From this it will be seen that a cylinder of cast-iron 12 in. in diameter inside, and exposed to a pressure of 4 tons per inch, must have a thickness of 8 in. If gun metal were substituted for cast-iron the thickness would be 2.4 in., and if wrought-iron were used the thickness would be 1.5 in.

* "Machinery and Millwork," page 495.

In practice, for obvious reasons, the lighter a hydraulic press can be made the better; it follows that wrought-iron would be the best possible material of which to make hydraulic presses, provided its use were not attended with counteracting disadvantages. Unfortunately it has hitherto been found impracticable to make hydraulic press cylinders of this material, because a straight longitudinal weld cannot be got to stand the enormous strain put upon it. It is just possible that hydraulic cylinders might be made on the coil system used in the manufacture of heavy guns, but if so made they would be very expensive, and there is a strong probability that they would not be uniformly successful, owing to a circumstance of which we have now to speak.

All the metals are more or less porous, and cast-iron in particular is so porous, that when the pressure reaches about 4 tons on the inch the water passes through the apparently solid walls of the press as fast as it can be pumped in by the very small plungers which must of necessity be used when the water is driven directly into the press cylinder by pumps. The accumulator press, described very fully in a recent impression, is not open to this objection, because the water is forced into it more rapidly than it can possibly escape, by the action of the differential ram. A cylinder made of coiled wrought-iron would probably suffer water to pass through its walls more rapidly than cast-iron, the flow taking place through the welds, which it is, practically speaking, impossible to make water-tight throughout. For these reasons no wrought-iron hydraulic press cylinders are made, so far as we are aware; nor does it appear that brass or gun metal possesses any advantage sufficient to counterbalance the enormous price, as compared with cast-iron, which a cylinder of either material would cost. But three materials are in ordinary use. These are cast-iron, steel, and malleable cast-iron. As regards the first, we have nothing new to say; as regards the second, although steel is sufficiently promising, up to the present comparatively very little has been done in the production of hydraulic presses by its aid. The steel can only be used in one way; any cylinder made of it must be cast as a cylinder; and the moment we come to

deal with the great masses of metal unavoidably present in large presses, we encounter difficulties in using steel which greatly enhance the cost of manufacture. Very few establishments in the world, for example, could cast from pots a steel cylinder 15 ft. long and 12 in. or 14 in. in diameter inside. Krupp could no doubt turn out any number of pot steel cylinders, and Messrs. Vickers, of Sheffield with their splendid appliances, make not a few. That such cylinders are successful we see no reason to doubt; but their cost is of necessity very much greater than that of cast-iron cylinders. On the other hand, it is urged, and with some show of reason, that at most, in the case of cotton presses, £100 sterling is about all the difference one way or the other between a press with a steel and a press with a cast-iron cylinder. And this sum represents such a fractional increase on the cost of packing each bale that it is of no moment whatever. That a properly made pot-steel cylinder must be better than cast-iron, in that it is lighter and is more easily carried up country in India or Egypt, and stronger, and therefore likely to last longer, is tolerably evident. The fracture of a cylinder in the midst of the packing season would cost its owner infinitely more than £100, if there was not a spare one ready at hand to replace the broken one. Very large steel cylinders might perhaps be made direct from the Bessemer converter at a very low price, but it is probable that the casting would be so porous that the water would escape through it more rapidly than through cast-iron. Bessemer metal is good for very little unless it is well hammered and consolidated subsequently to the act of casting. We do not say that it is impossible to design or construct machinery by which Bessemer steel cylinders of the size named above might be hammered and squeezed or otherwise consolidated after casting; but we do assert that the cost of carrying out the process would be fatal to its commercial success. No great difficulty would be encountered in the production of *small* cast steel-cylinders. But one material remains for consideration—that is malleable cast-iron. This material when good possesses, according to Professor Rankine, a tensile strength of 48,000 lbs. to the square inch, equal to that of good wrought iron. It has been before the world for many years, and most of our readers are doubtless familiar with it as presented to them in the shape of small-toothed wheels and light castings of all kinds. Some of them will be surprised perhaps to learn that Messrs. McHaffie, Forsythe, & Co., of Glasgow, are able to produce castings weighing as much as 12 tons, which are suitable for hydraulic cylinders. The firm have devoted peculiar attention to the manufacture of such cylinders, and have succeeded in turning out some excellent pieces of work. The precise details of the process are preserved as a secret by the firm. It must suffice to say that we have recently examined bars of malleable cast-iron which can be drawn, and are drawn, into nails for horseshoes in an ordinary blacksmith's fire. More remarkable still, sheets may be rolled in an ordinary sheet mill from cast bars, which sheets possess all the qualities of charcoal iron. If our readers will realize for themselves the fact that a bit of cast-iron can be heated white hot and forged into a horse nail, or rolled into a sheet not nearly so thick as the paper on which this article is printed, they will be in a position to understand how suitable this material is for the construction of hydraulic press cylinders. As an example of what may be done with the material, we may give the dimensions of a hydraulic press cylinder cast for Messrs. Nasmyth, Wilson, & Co., by Messrs. McHaffie & Co., in 1869. The internal diameter of the cylinder is 10½ in.; the thickness of the sides 2½ in. only; the total length 12 ft. 9¾ in. The thickness of the bottom 3¾ in. The working pressure will be over 2½ tons on the square inch. It may be thought that cylinders of this length—and others have been cast by Messrs. McHaffie as much as 15 ft. long in the rough—will warp in the annealing. This supposition is perfectly correct, they do twist and bend sometimes. When this takes place they are straightened by the aid of a press just as though they were made of wrought-iron; and we mention this fact because it tends to demonstrate the characteristics of the metal. As another instance of what may be done in malleable cast-iron, we may cite a press now being cast by Messrs. McHaffie for the Government. It is intended to bend armor plates. The

stroke is very short, but the diameter is not less than 2 ft. 5 in., and although the sides are but 5¼ in. thick they will be exposed to a strain of 4 tons on the square inch. The walls have been mape rather thinner than usual, in order to get the largest possible ram into the frame of the machine. By Molesworth's formula, if cast-iron were used, the sides of the cylinder must have been at least 18.75 in. thick ; but as it is well known that beyond a certain point no increase of thickness adds to the strength of a cylinder exposed to a bursting pressure, it is very doubtful if a cast-iron cylinder 2 ft. 5 in. diameter could be got to stand at all. The ram will have a diameter of about 2 ft. 4 in., and will exert a total strain on the plate to be bent of 2,463 tons, less the friction of the leather packing.

We shall not attempt to define what malleable cast-iron is. In grain it resembles steel, and he would be a rash man who attempted to assert that it was not steel. It is excessively close in texture, and in practice is found practically water-tight. Messrs. McHaffie have carried the manufacture of malleable cast iron to such perfection that, by altering the details of the process, they can totally alter the characteristics of the metal, producing either an excessively rigid, or an excessively soft and malleable material, the value ranging between £7 and £40 per ton. We regard the process as nothing less than a particular method of producing wrought-iron and steel in large and tolerably homogeneous masses. The cost of a malleable cast-iron cylinder is a little less than that of a pot steel cylinder of the same dimensions.

THE LAWS OF THE DEFLECTION OF BEAMS EXPOSED TO A TRANSVERSE STRAIN, TESTED BY EXPERIMENT.*

By Prof. W. A. NORTON, of New Haven, Conn.

I propose, on the present occasion, to communicate the principal results of a series of experiments made with an apparatus which I devised for the purpose of testing the theoretical laws of the deflection of beams exposed to a transverse strain.

[The apparatus was described in detail with the aid of several large diagrams. The following description will suffice to give an accurate idea of its essential features.]

It may be regarded as consisting of three different portions, viz. : (1) that which supports the stick to be experimented on ; (2) that which applies and measures the strain; (3) that which measures the deflection produced. The supporting apparatus consistsof 2 skeleton iron tables, each which is a rectangular wrought-iron frame 2¾ ft. long by 2 ft. broad, resting at the 4 corners upon cast-iron legs 2½ ft. high. The longitudinal bars of this frame are 1 in. broad by 2 in. deep. These tables are placed lengthwise on the same line, say a north and south line, and 1 ft. 4½ in. apart. Each of them supports a transverse sliding frame composed of 2 wrought-iron bars 1 in. by 2 in., placed 4 in. apart, and formed at the ends into 2 sliding saddle-pieces that rest upon the logitudinal bars of the table-frame. These sliding frames can be set at any distance apart, from 2 ft. to 6 ft. Upon each of them rests an iron plate ⅝ths of an in. thick, and fitted by grooves to the 2 iron bars, so as to be movable in the direction of their length, or crosswise, to the lengths of the tables. Upon these plates rest 2 cast-iron supports, each consisting of an upright pillar, 1½ in. square in cross section and 12 in. high, connected at the bottom with a plate that is supported by 4 levelling screws upon the sliding plates just described, and at the top with a plate 5 in. long (crosswise to the table-frames), 2½ in. broad and ⅝ths of an in. thick. The nearer edges of the top plates of these upright supports are bevelled off, so as to bring them immediately over the pillars. The stick experimented on rests immediately on these iron plates, and its effective length is the distance between their nearer edges.

The mechanical contrivance for applying the strain to the stick, like the supporting apparatus just described, is wholly

*From the Proceedings of the American Association for the Advancement of Science. Eighteenth Meeting.

made of iron, and consists of an upright screw, turning by means of female screws in. 2 horizontal plates fastened at their 4 corners to upright columns. These columns are firmly connected with an iron bed plate, which is placed between the table supports above described and securely fastened to the floor-joists by long screw-bolts. The screw-head is connected by intermediate pieces with an iron stirrup that rests crosswise upon the stick. There is a special arrangement, which cannot well be described here, by which these intermediate pieces are made to move in a truly vertical direction, and not partake, in any degree, of the revolving motion of the screw. One of the intermediate pieces referred to, is a Fairbank's spring dynamometer (essentially the same as Regnier's). The circular dial-plate reads from 1 lb. to 1,000 lbs. By means of the screw a power of 1,000 lbs. can be applied to the stick; but in the experiments the strain was in no instance carried higher than 500 lbs.

The apparatus for measuring the deflection produced, consists of a brass lever of 2 arms, each 5 in. long, one end of which is depressed by the middle of the bent stick, and the equal rise of the other is measured by a micrometer-screw. This micrometer-screw reads to one ten-thousandth of an inch. The lever is placed crosswise to the length of the stick, and opposite its middle. It passes through a vertical slot in the iron stirrup that rests upon the middle of the stick, and presses by a blunt steel knob against the under side, the farther end of the lever being made slightly heavier than the other, so as to secure a moderate pressure. The arrangement for supporting the lever consists of a wooden strip $6\frac{1}{2}$ ft. long, $2\frac{3}{8}$ in. deep, and $\frac{1}{2}$ in. thick, stiffened along the top by a strip of brass. This is secured to the pillars of the two upright supports, by clamping-pieces, which firmly hold it at a distance of 5 in. from the centres of the pillars and parallel to the length of the stick. Upon this supporting strip rests a sliding saddle-piece, having a small flat plate on the top, and adjustable by horizontal screws that pass through its vertical side plates and press against the vertical sides of the wooden strip. Upon the top plate of this saddle-piece rests, by means of four levelling screws, another small plate, upon which the knife-edge of the lever immediately rests. From the vertical side-plate of the saddle-piece that is farthest from the stick, extends a small horizontal bar, 6 in. long. This lies directly under the farther half of the lever. Near its farther end the micrometer-screw passes through it from below upward, and touches the under side of the lever, at a distance of 5 in. from the knife-edge support. The contact of its rounded point with the lever is observed with a microscope. The screw-head, adapted to the lower end of the screw, is 2 in. in diameter. Its outer vertical edge is silvered, and graduated to read to thousandths of an inch; but a small vertical wire fastened to the bar above it, past which the screw-head moves, subdivides the smallest space on the graduation, so as to make it possible to read to the one ten-thousandth of an inch. Since the knife-edge of the lever is at the same distance from the point of contact with the upper end of the micrometer-screw and from that with the middle of the under side of the stick, the micrometer readings are the linear deflections of the middle of the stick. It will be observed that the depressions of the knob of the lever under the middle of the stick, will be the actual deflections; since the support of the fulcrum of the lever is firmly connected with the upright supports of the stick, and will partake of any depression that they may experience from any settling of the apparatus under the action of the force that produces the deflection. It may be remarked here that it was ascertained, by an independent set of experiments, that the actual depression of the apparatus was very small; only from two to three-thousandths of an inch for every 100 lbs. of pressure.

The manner of conducting the experiments will be readily understood. The inner edges of the top surfaces of the upright supports upon which the stick is to rest, are set at a distance apart equal to the proposed effective length of the stick, either 2 ft., 4 ft., or 6 ft. These surfaces are carefully levelled and adjusted to the same horizontal plane. The lower plates of the upright supports are firmly clamped to the sliding frames on which they rest, by portable clamps. The stick is then put in its place, the iron stirrup placed crosswise upon its middle, and connected by a

sliding bolt and key with the upper end of the closed spring of the dynamometer. The apparatus for measuring the deflections is also levelled and adjusted. The screw is then slowly turned until the index of the dynamometer indicates 100 lbs., 200 lbs., or any other force of pressure it is proposed to apply, and the reading of the micrometer-screw indicates the linear deflection of the middle of the stick produced by the pressure applied.

The experiments were made upon white pine sticks of various lengths, fron 2 ft. to 6 ft., and various breadths and depths, from 1 in. to 4 in. The results are derived from the means of a large number of experiments. As an additional test the experiments were repeated upon a second set of sticks.

The received theoretical formula for the deflection of beams of a rectangular cross section of uniform dimensions, is

$$f = m \frac{Pl^3}{4\,Ebd^3}$$

in which m is a constant, P the power applied, E the modulus of elasticity, l the length, b the breadth, and d the depth of the stick. For the case of a beam resting freely on two supports and loaded in the middle, to which the experiments were entirely confined, this becomes

$$f = \frac{Pl^3}{4\,Ebd^3}.$$

If this formula be correct, then the following laws must be true.

(1.) The deflection is directly proportional to the pressure.

(2.) It is inversely proportional to the breadth.

(3.) It is inversely proportional to the cube of the depth.

(4.) It is directly proportional to the cube of the length.

We will now compare each of these laws with the experimental results obtained.

First Law. The deflection is directly proportional to the pressure. The following table contains a few of the results that serve to test this law. The first three columns give the lengths, breadths, and depths of the sticks, and the last column gives the differences between the deflections produced by the two pressures given in the column headed Difference of Pressures.

The deflections for the first 100 lbs. of pressure are not included, for the reason that there is more liability to error in observing the absolute deflection than in observing the increments of deflection produced by each 100 lbs. of augmented pressure, starting from a pressure of 100 lbs. The actual results for the first 100 lbs. are given, for comparison, at the bottom of the table.

TABLE I.

Sticks.			Diff. of Pressures, in Pounds.	Diff. of Deflections, in Inches.
Length.	Breadth.	Depth.		
2 feet.	4 inches.	2 inches.	100 to 200	0.0114
2 "	4 "	2 "	200 to 300	0.0102
2 "	4 "	2 "	300 to 400	0 0090
2 "	4 "	2 "	400 to 500	0.0090
4 feet.	2 inches.	3 inches.	100 to 200	0.0459
4 "	2 "	3 "	200 to 300	0 0460
2 feet.	3 inches.	2 inches.	100 to 200	0.0159
2 "	3 "	2 "	200 to 300	0.0135
2 "	3 "	2 "	300 to 400	0.0127
2 feet.	2 inches.	3 inches.	100 to 200	0.0083
2 "	2 "	3 "	200 to 300	0.0084
2 "	2 "	3 "	300 to 400	0.0080
2 feet.	4 inches.	2 inches.	0 to 100	0.0119
4 "	2 "	3 "	0 to 100	0.0477
2 "	3 "	2 "	0 to 100	0.0164
2 "	2 "	3 "	0 to 100	0.0092

The following table gives the deflections for 100 lbs., 200 lbs., 300 lbs., etc., pressure:

TABLE II.

Sticks.			Pressures, in Pounds.	Deflections, in Inches.
Length.	Breadth.	Depth.		
2 feet.	4 inches.	2 inches.	100	0.0119
2 "	4 "	2 "	200	0.0233
2 "	4 "	2 "	300	0.0335
2 "	4 "	2 "	400	0.0426
2 "	4 "	2 "	500	0.0516
4 feet.	2 inches.	3 inches.	100	0.0477
4 "	2 "	3 "	200	0.0936
4 "	2 "	3 "	300	0.1396
2 feet.	3 inches.	2 inches.	100	0.0164
2 "	3 "	2 "	200	0 0323
2 "	3 "	2 "	300	0.0458
2 "	3 "	2 "	400	0.0585
2 feet.	2 inches.	3 inches.	100	0.0092
2 "	2 "	3 "	200	0.0181
2 "	2 "	3 "	300	0.0264
2 "	2 "	3 "	400	0.0344

It appears from the results given in Tables I. and II., that the deflection is approximately proportional to the pressure; but, strictly speaking, increases according to a less rapid law. The probable explanation of this discrepancy between theory and fact, is, that as the force of pressure increases, the neutral axis of the cross section of the stick shifts its position, and its distance from the centre of gravity of the cross section augments as the pressure becomes greater. From this cause the moment of the resistance to flexure increases indirectly with the pressure, at the same time that it increases directly from the augmented strains of the fibres. The increased moment of resistance to flexure resulting from this shifting of the neutral axis, should be attended with a diminished increment of deflection for the same increment of pressure.

Second Law.—The deflection is inversely proportional to the breadth. Table III. will serve to test this.

TABLE III.

Sticks.			Obs. Deflection for 100 Lbs., in Inches.	Cal. Deflection for 100 Lbs., in Inches.	Difference, in Inches.	Ratios of Error.
Length.	Breadth.	Depth.				
2 feet.	1 inch.	2 inches.	0.0423	0.0423	....	..
2 "	2 "	2 "	0.0195	0.0211	+0.0016	1-12
2 "	3 "	2 "	0.0147	0.0141	−0.0006	1-24
2 "	4 "	2 "	0.0106	0.0106	0.0000	....
4 feet.	1 "	2 "	0.2858	0.2858	....	....
4 "	2 "	2 "	0.1200	0 1429	+0.0229	1-5
4 "	3 "	2 "	0.0983	0.0952	−0 0031	1-32
4 "	4 "	2 "	0.0624	0.0714	+0.0090	1-7

The numbers in the column of calculated deflections are obtained by assuming the observed deflection for the smallest breadth (1 in.), and computing the deflection for the other breadths on the supposition that it is inversely proportional to the breadth. The last column gives the ratios of the differences between the observed and calculated deflections, given in the preceding column, to the observed deflections. The observed deflections answer to an increase of pressure from 100 lbs. to 200 lbs., or 200 lbs. to 300 lbs. It will be seen that the errors are some plus and others minus, and that the ratios of error are small fractions. They are, how-

ever, too great to be attributed entirely to errors of observation; but not greater than may reasonably be ascribed to differences in the moduli of elasticity of the different sticks, and to the greater shifting of the neutral axis in the case of the sticks most strained, in connection with possible errors of observation.

Third Law.—The deflection is inversely proportional to the cube of the depth.

It soon became evident, in the course of the experiments, that this law could not be regarded as even approximately true, except in the cases of sticks, or beams, whose length bore a high proportion to their depth. The following comparisons of observed with calculated deflections will show that it fails in the case of sticks two feet in length.

TABLE IV.

Sticks.			Ratios of bd^3.	Obs. Deflection, in Inches.	Cal. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
Length.	Breadth.	Depth.					
2 feet.	2 ins.	1 inch.	....	0.1414	....	....	....
2 "	1 "	2 "	1 to 4	0.0423	0.0353	−0.0070	1-6
2 "	3 "	2 "	....	0.0147	....	....	....
2 "	2 "	3 "	1 to $2\frac{1}{4}$	0.0084	0.0065	−0.0019	1-4.4

TABLE V.

Sticks.			Ratios of d^3.	Obs. Deflection, in Inches.	Cal. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
Length.	Breadth.	Depth.					
2 feet.	2 ins.	1 inch.	....	0.1414	....	....	....
2 "	2 "	2 "	1 to 8	0.0195	0.0177	−0.0018	1-11
2 "	2 "	3 "	1 to 27	0.0084	0.0052	−0.0032	1-2.6

The calculated are all less than the observed deflections. The same is true when sticks of greater length than 2 ft. are taken, but the errors are smaller in proportion as the length is greater. It appears, therefore, that the deflection decreases according to a less rapid law than the inverse cube of the depth.

Fourth Law.—The deflection is directly proportional to the cube of the length.

The experiments show that this law fails, as well as the third.

TABLE VI.

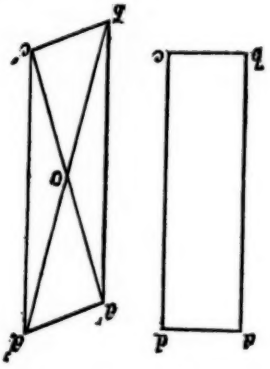
Sticks.			Ratios of l^3.	Obs. Deflection, in Inches.	Cal. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
Length.	Breadth.	Depth.					
2 feet.	2 ins.	2 ins.	....	0.0195	....	....	....
4 "	2 "	2 "	1 to 8	0.1200	0.1560	+0.0360	1-3.33
2 "	2 "	3 "	....	0.0084	....	....	....
4 "	2 "	3 "	1 to 8	0.0460	0.0672	+0.0212	1-2
2 "	3 "	2 "	....	0.0147	....	....	....
4 "	3 "	2 "	1 to 8	0.0983	0.1176	+0.0193	1-5
2 "	4 "	2 "	....	0.0106	....	....	....
4 "	4 "	2 "	1 to 8	0.0624	0.0848	+0.0224	1-2.8

We may conclude, from these results, that the deflection increases according to a less rapid law than the cube of the length of the stick. We have already seen that it decreases in a less rapid proportion than the inverse cube of the depth. It follows, therefore, that the true formula for the deflection probably contains at least one additional term, which varies less rapidly than as the cube

of the length directly and the cube of the depth inversely; or, in other words, contains l in the numerator, and d in the denominator, each raised to a lower power than the cube. Now, if we consider attentively the changes that must occur in the relative positions of the molecules within a stick or beam, when it is subjected to a cross strain, we may perceive that a cause of deflection exists which has hitherto been disregarded, or deemed too insignificant in its effects to be taken into account.

It is plain that when a stick or beam, of a uniform rectangular cross section, resting on two supports, is loaded at its middle, a vertical force equal to one-half the weight is transmitted to each support, by the slipping of each vertical section, or lamina, upon the next, until a vertical force of resistance is called into play equal to half the weight. As each section must transmit this same force to the next, the slipping of one section upon another must be the same from the middle to the end. The section at the middle will be directly depressed, from this cause, by an amount equal to the sum of all these displacements that occur between the middle and the end, or to any one displacement multiplied by the number of sections, or indefinitely thin laminæ, in this interval. This depression should, then, be directly proportional to the half-length, or length, of the stick. If we compare sticks of the same length but different cross sections, the number of fibres that are subjected to this cross strain, or the number of material points in each cross section whose vertical resistance will be called into operation by the slipping of this section upon the next, will be proportional to the area of the cross section, and hence the amount of the relative sliding displacement will be inversely proportional to this area. It will be seen, then, that the sinking or linear deflection of the middle of the beam, thus directly resulting from the slipping of contiguous vertical sections, may be represented by the expression $c\,\frac{Pl}{bd}$; in which P is the load, l the length, b the breadth, and d the depth of the beam, and C a constant that must be determined by experiment.

The theoretical deflection given by the formula which has been under discussion, is due to longitudinal strains on the fibres, indirectly resulting from the same slipping of contiguous sections. If ab and cd represent two vertical cross sections, indefinitely near to each other, of which ab



is nearest the middle of the beam, the transmission of the action of the half-weight will cause ab to slip relatively to cd until a vertical resisting force comes into operation equal to the half-weight; and the rectangle $abcd$ will take the form of the oblique parallelogram, $a'b'c'd'$. The diagonal ac will therefore be shortened, and bd lengthened. Accordingly a strain of compression will come into operation along $a'c'$, and a strain of extension along $b'd'$. The reactions to these strains will take place, along $a'c'$ from the middle o toward a', and from o toward c', and along $b'd'$ from b toward o, and from d' toward o. As a consequence, the points a' and d' will be urged by equal forces toward the left, or toward the middle of the beam, and the points $b'c'$, by the same forces, toward the right. The sum of the first two forces will then be a longitudinal strain of compression on the upper fibre, and the sum of the last two an equal strain of extension on the lower fibre. It will be observed that the strains here considered as confined to the upper and lower fibres, are actually distributed over all the fibres above and below the middle fibre of the beam.

The conclusions here arrived at with regard to one indefinitely small rectangle, $abcd$, will be equally true of any other that may be considered between the middle and end of the beam; and the same longitudinal strains will be developed by the slipping of contiguous sections in

each rectangle. The entire longitudinal strains on the fibres, at the middle, will then be the sum of the individual strains developed in all the rectangles of the half length of the beam. The ordinary equation of equilibrium of a beam may be readily made out from the present point of view; but we have now only to consider the matter of deflection. It will be seen that the movements, to the left and right, of the angular points of the parallelogram $a'b'c'd'$, that have been signalized, will be attended with a turning of the whole parallelogram from right to left around its centre o. The direct tendency to rotation will be the same for each parallelogram of the half length of the beam, but owing to the propagation of the longitudinal strains on the fibres developed at each parallelogram, from the end to the middle, the actual compressions and elongations will be greatest at the middle, and the actual rotation of the parallelogram there will be the greatest. The deflection consequent upon the elongations and compressions of the fibres, is the joint result of the rotary movements of all the parallelograms in the half length of the beam; and it is represented by the formula which has been under discussion.

It would seem, then, that the true theory of deflection conducts to the following formula, in the special case of a beam resting on two supports and loaded in the middle.

$$f = c\frac{Pl}{bd} + \frac{Pl^3}{4\,Ebd^3}$$

Let us now proceed to compare this formula with our experimental results. For this purpose we will determine the values of the two constants C and E for each individual stick, and compare the several values obtained. If the formula be correct, the different sticks all in precisely the same mechanical condition, and the experiments perfectly accurate, we should get the same values for these constants in the case of each stick. But the experiments are liable to more or less of error, and the sticks may differ materially from one another in their mechanical condition; and even where they do not, as the actual deflections experienced are so different with sticks of different dimensions, any changes in the values of the constants that may result from the shifting of the position of the neutral axis, under the operation of the strains, should differ more or less. The derived values of the constants may therefore differ among themselves, within certain limits, without leading us to conclude that the formula is probably at fault.

TABLE VII.

Sticks.			Difference of Extreme Pressures.		Difference of Intermediate Pressures.	
Set No. 1.						
l.	*b.*	*d.*	*E.*	*C.*	*E.*	*C.*
Feet.	Inches.	Inches.	Lbs.		Lbs.	
2, or 4	2	1	1,359,500	0.0000108	1,308,430	0.0000082
2	2, or 3	3, or 2	1,566,809	0.0000100	1,579,960	0.0000095
4	2, or 3	3, or 2	1,584.820	0.0000087	1,560,800	0.0000078
2, or 4	4	2	1,552,000	0.0000140	1,501,200	0.0000127
2, or 4	2	2	1,481,800	0.0000108	1,423,600	0.0000084
Means.....			1,508,986	0.0000108	1,474,798	0.0000093
Set No. 2.						
Feet	Inches.	Inches.				
2, or 4	3	2	1,277,729	0.0000084	1,254,000	0.0000080
2, or 4	3	3	1,295,984	0.0000089	1,315.000	0.0000088
2, or 4	4	2	1,558,900	0.0000110	1,542.860	0.0000107
2, or 4	2	2	1,561,822	0.0000084	1,600.000	0.0000100
Means.....			1,423,609	0.0000092	1,427,965	0.0000094

The above table contains the values of C and E, calculated from the deflections due to 100 lbs., for two sets of sticks of the same dimensions. They were all over 4 ft. in actual length, but in the experiments the effective lengths taken were either 2 ft. or 4 ft. The values of E and C were obtained, in some instances, by

taking the deflections for the same breadth and depth, but different lengths (either 2 ft. or 4 ft.), and in other instances by taking the deflections for the same length, but different breadths and depths. The results of two sets of calculations are given in the table. In the one the deflections answering to the least and greatest strains are taken, and the deflection due to 100 lbs. computed from the difference of these by simple proportion; in the other the same is obtained by taking the deflections answering to strains, or pressures, intermediate between the extreme strains.

The general formula applicable to white pine sticks of the general quality used in these experiments, will be obtained by taking the mean of the several values of E and C given in the above table. To test the theoretical formula we have obtained, we will take the mean values of E and C, for the second set of sticks, given at the bottom of the fourth and fifth columns, viz.: E=1,427,965 lbs., and c=0.0000094. We thus have

$$f = 0.0000094\,\frac{Pl}{bd} + \frac{Pl^3}{5{,}711{,}860 \times bd^3}$$

or, taking $P = 100$ lbs.,

$$f = 0.00094\,\frac{l}{bd} + \frac{l^3}{91{,}418.6 \times bd^3}$$

The following table contains the values of f calculated by this formula, and the results of a comparison of the calculated values with the deflections observed.

TABLE VIII.

Sticks.			Cal. Values of f, in Inches.	Obs. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
l.	b.	d.				
4 feet.	3 ins.	2 ins.	0.0882	0.0983	−0.0101	1-9.7
2 "	3 "	2 "	0.0140	0.0147	−0.0007	1-21
4 "	2 "	3 "	0.0434	0.0460	−0.0026	1-18
2 "	2 "	3 "	0.0082	0.0084	−0.0002	1-42
4 "	4 "	2 "	0.0661	0.0624	+0.0037	1-17
2 "	4 "	2 "	0.0104	0.0090	+0.0014	1-6.4
4 "	2 "	2 "	0.1323	0.1200	+0.0123	1-9.8
2 "	2 "	2 "	0.0208	0.0195	+0.0013	1-15

The comparative accuracy of the old and new formulas, will be seen on comparing the ratios of error in Tables IV., V., and VI., and Table VIII. It should be added that the results given in Table IV. are from calculations made in each instance on sticks which are identically the same, whereas those in Table VIII. are affected with the errors resulting from the fact that the values of E and C are the mean values obtained from a number of different sticks, which may differ more or less in their mechanical condition. If we take the average values of these constants given in the table for the stick 3 in. by 2 in. in cross section, and obtained by taking the deflections answering to the lengths, 2 ft. and 4 ft., the formula thus obtained gives, for these transverse dimensions and the lengths, 2 ft. and 4 ft., respectively, four results, the ratios of error of which lie between $\frac{1}{1500}$ and $\frac{1}{1200}$.

TABLE IX.

Sticks.			First Term.	Second Term.	Ratio.	Sum.
l.	b.	d.				
			In.	In.		In.
4 feet.	3 ins.	2 ins.	0.00692	0.08952	1-12	0.0964
4 "	2 "	3 "	0 00692	0.03979	1-5.7	0.0467
4 "	4 "	2 "	0 00658	0.0554	1-8	0.0620
4 "	2 "	2 "	0.01000	0.1106	1-11	0.1206
4 "	1 "	2 "	0.01776	0.2681	1-15	0.2858
2 "	3 "	2 "	0.00346	0.01119	1-3.2	0.0146
2 "	2 "	3 "	0.00346	0.00497	1-1.4	0.0084
2 "	4 "	2 "	0.00328	0.00693	1-2	0.0102
2 "	2 "	2 "	0.00500	0.01383	1-2.8	0.0188
2 "	2 "	1 "	0.00990	0.13150	1-13	0.1414
2 "	1 "	2 "	0.00990	0.03301	1-3.3	0.0429

Let us compare the values of the first and second terms of the formula. This is done in Table IX. The values of E and C taken in the formula, are the individual values for each stick given in the second and third columns of Table VII.

It will be observed that the value of the first term is in general comparatively larger for the length of two feet, than for that of four feet; and in two instances is as large as one-half the second term.

If now we divide the first term by the second, we obtain as the general expression of their ratio,

$$4\,E\,C\frac{d^2}{l^2};$$

from which we see that it is proportional to $\left(\frac{d}{l}\right)^2$. When

$$\frac{l}{d} = \sqrt{4\,E\,C},\ 4\,E\,C\frac{d^2}{l^2}$$

becomes equal to unity, and the first term equal to the second. When $\frac{l}{d}$ has a less value than this, the first term is greater than the second. Taking the mean values of E and C, given in the last two columns of Table VII., for the first set of sticks, we have

$$\sqrt{4\,E\,C} = 7.41.$$

The mean values given in the same columns for the second set of sticks, give

$$\sqrt{4\,E\,C} = 7.33.$$

If, therefore, the length of a white pine stick be less than about seven and one-third times the depth, the deflection from the cause heretofore neglected becomes greater than from the cause to which the whole deflection has hitherto been ascribed. When the length and depth are equal, it is nearly fifty-five times greater; from which it appears that in this case the deflection directly due to the slipping of contiguous vertical laminæ, so greatly preponderates over that indirectly resulting from the same by reason of the longitudinal strains communicated to the fibres, that the latter is comparatively inappreciable.

It will be seen, from the general expression for the ratio of the two terms, above obtained, that the formula for the deflection may take the following form:

$$f = \frac{Pl^3}{4\,Ebd^3}\left(4\ EC\frac{d^2}{l^2} + 1\right).$$

I have made, with the same apparatus, a series of experiments on the degree of set, or residual deflection, communicated to sticks by varied strains, and under various circumstances, and obtained interesting and valuable results. The discussion of these experiments is reserved for another occasion.

ECONOMICAL STEAM ENGINES.

From "The Engineer."

The compound engine has been so long know to engineers that it is certain nothing remains to be learned by properly qualified persons, as to the conditions under which it may be most successfully employed, or the results that may be expected from it. To many so-called mechanical engineers, however, it is beyond doubt that the compound engine is, to all intents and purposes, a novel contrivance; and we are not surprised to find numerous firms just now embarking on its construction, or adopting it in their mills or in their steamships, with astonishing zest and relish; but those to whom the history of the steam-engine is familiar know well that just such a passion for compounding engines, as that which is now apparent in a few districts existed many years ago, and died a natural death. We have no intention of deprecating the use of compound engines, but we think it well to point out to employers of steam power, that the object they seek to attain by using them, can under the circumstances which usually obtain, be easily secured in a far more simple way; while we add that the use of the compound engine is only advisable under circumstances which do not now obtain at all, except in very rare cases.

It is, no doubt, very desirable that as little coal as possible shall be burned in obtaining a given amount of power, always providing that the use of a very small quantity of coal be not attended by a very large increase in the expenditure on other items, such as repairs, tallow, grease, brass, loss of time due to the engine standing idle, etc. We have dwelt

on these points so fully in two articles on economical steam-engines, which have preceded that which we are now writing, that it is unnecessary to refer to them more fully. We shall assume that the reader fully understands that the relative economy of different forms or systems of steam machinery must be estimated, not by the cost of coal alone, but by the entire cost of steam power as shown by each year's returns, and proceed to explain under what circumstances manufacturers are justified in adopting compound engines.

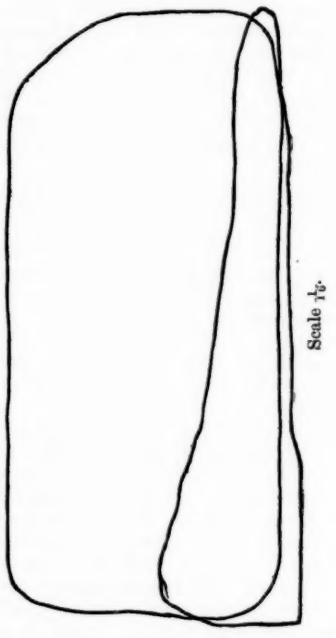
In the first place, then, the compound engine should never be used unless steam of very great pressure indeed is employed. To the use of steam as much as 500 lbs. per square inch we see no objection whatever, provided everything is made to suit. But it must be understood that a power-producing machine of this kind bears precisely the same relation to the ordinary commercial steam-engine, that one of Arnold's or Frodsham's chronometers bears to a good sound workman's watch. From beginning to end, in design, in construction, and in dimensions, it sets popular preconceived notions of the steam-engine at defiance. It is necessarily expensive to begin with, but if made in the proper way by a man who understands what he is about, it may continue perfectly efficient for many years, without any very great outlay on repairs. Such an engine as we speak of may be seen running now in Mr. Perkins' workshops, near King's Cross. The load on the safety-valve is 600 lbs. on the sq. in., and the total admission of steam is for 3 in. of the stroke of a 6 in. piston, the length of the crank being 6 in. There are in all three cylinders, and this engine has been known to indicate 100-horse power with this admission, the vacuum being 25 in. We shall enter into no details of the construction of this engine now; we propose to supply them to our readers in due course. We only refer to the engine at all here, because it affords an apt practical illustration of the conditions under which compounding is advisable, and of the difference between ordinary so-called high-pressure engines, and engines in which high pressure and enormous measures of expansion are used as they ought to be used.

We hold that the great mistake of the day lies in the use of steam, which is neither low nor high pressure, which, while entailing nearly every possible difficulty with which the engineer can have to contend, gives no collateral advantage over engines working with steam of much lower pressure. We believe that the logic of facts will bear us out when we make the somewhat startling assertion that nothing is to be gained in ordinary land practice by using a higher pressure than 100 lbs., or a greater measure of expansion than 7 or 8 times, until we employ a radically different type of engine and boiler, and resort to pressures of 250 lbs. to 500 lbs. on the sq. in., and measures of expansion of from 14 to 30 times. Over and over again have engines been "compounded" and "McNaughted," and fitted with all manner of strange and fantastical valve gear, without securing one atom of real economy. The McNaught or compound cylinders have been taken out again or discarded, as in the case of the Mooltan, one of the Peninsular and Oriental Company's mail steamers, which was fitted with double-cylinder compound engines. On one voyage a small cylinder was disabled, and steam was worked for the remainder of the run through the large cylinder in the ordinary way. On examining the coal account it was found that this was the most economical run the ship had ever made, though very far from being the slowest. The boiler pressure was but 25 lbs. above the atmosphere. "Compound engines for such pressures are simply gross absurdities," cries the intelligent critic; but, let us ask, where is the line to be drawn? We say at 40 lbs., or thereabouts, at sea, and at 100 lbs., or thereabouts, for stationary engines. After that let us begin compounding by all means; but we equally maintain that the limit of economical working is reached in ordinary engines at 100 lbs., and that the next step must be the adoption of a totally different form of generator and engine from anything now in general use, and a jump to pressures of 250 lbs. to 500 lbs. on the sq. in.

It is well to avoid the risk of being misunderstood on this point, and we therefore explain why it is that we have made the preceding statement. The reason is this: We do not think it to be good practice to use steam of more than

100 lbs. pressure in large simple engines; that is to say, in engines running at moderate speeds, and indicating 300 or 400-horse power, with high measures of expansion. When this point is reached the balance of advantage will probably lie with the compound engine, if thoroughly well made, nothwithstanding its complexity and its costliness; but this very complexity and costliness will usually suffice to render the economy gained by the resort to an additional 20 lbs. or 30 lbs. pressure absolutely nothing; so that a simple engine working 100 lbs. steam may be quite as economical as a compound engine working at a higher pressure and measure of expansion. But the moment an engine is compounded we enter, so to speak, a different sphere of conditions; and the prudent engineer, having first considered well whether he will or will not compound, and having decided that he will, should at once make up his mind to take advantage of all that compounding can give him, and consequently jump, at one spring, to very large measures of expansion and very high pressure, from which alone he can expect to receive an adequate return for the trouble and cost entailed by compounding.

Furthermore, it will be well to explain here why we limit the maximum of economical pressure at sea to 40 lbs., ordinary engines being used. The reason is that marine engines are exposed to rough usage in the way of shocks and strains, of which land engines, if we except those used in iron-works, know nothing. A marine engine fit for 40 lbs. at sea should be quite safe with 100 lbs. on land. As regards land engines, we are quite at a loss to understand why any necessity whatever should exist for the use of a second or compound cylinder if pressures not greater than 100 lbs., or measures of expansion not greater than 10 times, are employed. Let the single-cylinder engine have just the same weight of material employed in its construction, and that of its appurtenances, as is divided over two cylinders, etc., in the compound engine, and there will be little fear of a break down. It will be said that the motion of a single engine will be very unequal as compared with that of a compound engine. Not a bit of it! It is well known that no work that can be thrown on an engine is more irregular than that of rolling wide and long thin sheets — "doubles" or "lattens." It is, in the second place, evident that whether the application of power in the case of a constant load is irregular, or the power being constant



the load is irregular, the effect on the speed of the engine is the same. Now, we have stood beside an engine with a 32 in. cylinder, 5 ft. stroke, making 40 revolutions per minute, roiling sheets, and in the engine-house it was impossible to know whether a sheet was going through the rolls or not, except by seeing that the expansion cam was shifted from one grade to the next for a moment by a good governor. The load was increased for about five seconds, while the sheet was passing through, to an amount which may be estimated from the annexed diagram, which we recently took, not from this, but from a nearly similar engine. The small diagram shows the load when the mill is empty, that is to say, when the sheet is not between the rolls. The large diagram, the work done while the sheet is passing through. It will be understood, however, that the average diagram usually taken while a sheet is being rolled, will

be neither as high as the one nor as low as the other, for sufficiently obvious reasons. Now, why was it that the speed of the engine was so little affected? The governors were good, but of the common type; they were not Porter's, nor were they parabolic. The regularity of motion was due to the fact that on the engine shaft was hung a fly-wheel 28 ft. in diameter, and weighing not less than 60 tons. Fancy any ordinary cotton-spinning factory or flour mill with a 60-ton fly-wheel, on a 32 in. cylinder engine too! The engineer who proposed to put down such a wheel would be laughed at, yet in nine cases out of ten the use of a properly proportioned fly-wheel would render the compounding of engines totally unnecessary. A fly-wheel costs, say, to begin with, £6 10s. per ton if of a large size, and when once up it never costs another sixpence. The cost of a compound engine, as compared with a single engine, will be much more, in the first place, than the difference in price due to the difference in weight of a heavy fly and the light fly, and the extra cylinder will cost as much for its maintenance, or very nearly as much as a second engine, unless the workmanship is perfectly unexceptionable.

From all this we come to the conclusion that for pressures of about 100 lbs., and a ten-fold expansion, it is better to employ a heavy fly-wheel than a second cylinder, to insure regularity of motion.

The next difficulty lies in the fear of mischief being wrought by the shock of high steam on a large piston. There are two ways out of this labyrinth. The first is, to make the engine sufficiently strong; to which the answer is, that it costs too much; to which we reply that it will not cost as much as a second cylinder, etc. The other way is; don't use a large piston; instead, have a high piston speed; to which the answer is; that high piston speed engines are not durable, but knock themselves to bits; to which we reply, that the knocking to bits is due, not to the high piston speed, but to the very rapid change in the direction of the motion of the moving parts. Instead of big pistons moving slowly, or little pistons driving cranks making a fabulous number of revolutions per minute, let us employ engines with small pistons, a moderate number of revolutions per minute, and long strokes. The only things to be taxed by this arrangement are the crank and its shaft; and in these days of steam hammers and heavy forgings, there is no difficulty whatever in making crank and shaft perfectly secure. American engineers have much, perhaps, to learn from us, but we have to learn from them how to combine high piston speed with slow reciprocation. Let us cite as cases in point the steamboats Vanderbilt, with a 65 in. cylinder and 12 ft. stroke, making 22½ revolutions per minute; the City of Buffalo, 76 in. cylinder, 12 ft. stroke, 19½ revolutions per minute; the Golden City, Pacific mail steamer, 105 in. cylinder, 12 ft. stroke, 17½ revolutions; the Metropolis, with a similar engine as regards dimensions, has made 20 revolutions; the engines of the New World, a paddle steamer 420 ft. long, on the Hudson, has made 20 revolutions per minute, stroke 15 ft., 76 in. cylinder; while the Richard Stockton, 50 in cylinder, 10 ft. stroke, made 30 to 32 revolutions. All these are overhead beam engines, the worst possible form of engine for high piston speeds; but here we have comparatively small pistons developing an enormous power, due to the great speed at which they run, although the number of revolutions is very small.

By the use, therefore, of small pistons, long strokes, and of heavy fly-wheels, steam of 100 lbs. may be expanded comfortably to ten times in a single cylinder; that is to say, there will be neither undue strain nor inconvenient irregularity of motion, nor any liability to break down or get hot bearings, due to too great a rapidity of reciprocation. Whether any advantage is likely to accrue from expanding 100 lbs. of steam more than six or seven times, we must reserve for consideration in another article.

In the six years of 1862-67 1,268 persons were killed upon the railways of the United Kingdom, and 4,426 persons were injured; among them were 112 passengers killed and 3,897 injured without any fault of their own, and 97 passengers killed and 29 injured owing to their own misconduct or want of caution, or at least attributed to this cause by the railway companies. In those six years the railway companies paid £1,460,568 as compensation for personal injuries done upon the railroads.

THE RESISTANCE OF PRISMATIC SECTIONS.

Translated from "Expose de la Situation de La Mécanique Appliquée."

Improvements in experimental methods have, during our epoch, kept pace with improvements in analytic methods. Formerly experiments were made upon pieces of small dimensions; and the constants which were determined were applied to the same materials, whether employed in the smallest or the greatest works. The old experimenters followed this method; Buffon with wood, Rondelet and Rennie with materials employed in masonry, Barlow and Tredgold with iron and steel, Vicat with mortars. They had in view generally the determination of four quantities: the specific gravity, which enters into the calculation of the proper loads; the coefficient of elasticity; the limit of elasticity, and the breaking weight. A fifth remained to be determined, that is, the limit of the load for actual construction consistent with durability. These experiments, repeated by a great number of observers, under the most diverse conditions, have thrown great light upon engineering art. The tables of Genieys, in the section on the resistance of materials, present an excellent resumé in a succinct form.

The problem of the reaction upon pieces at their supports which leads to particular cases, has been studied experimentally; and Rondelet, in his "Art de Batir," reviewing all the facts collected by his predecessors with reference to the compression of wood, has given a practical rule, which indicates the successive reductions to which the limit of load should be subjected, as the ratio of the length of the piece to its least transverse dimension is increased. It follows from this rule that a piece 24 times as long as the side of its square section upon which it stands, will sustain only half the pressure which it would if reduced to the form of a cube. This subject has been taken up and perfected by the English engineers, whose experiments we shall now notice.

Among these experiments the most numerous and remarkable are those of M. Hodgkinson; the results of which were published in 1846, and which were translated in 1855, by M. Pirel in "Les Annales des Ponts et Chaussées." The experiments of Hodgkinson were intended to determine with precision the extreme resistance of steel to traction, to flexion, and to transverse strains, and to deduce from the observed phenomena the best form to give to solids made of this material. The old observers, always pre-occupied with the use of formulas deduced from the theory of flexion, did not attach great importance to the phenomena attendant upon rupture, and the majority neglected to extend their experiments beyond the limit of elasticity where the formulas cease to be applicable. The observations of Hodgkinson sensibly enlarged the field of the old experiments.

About this time the extended use of metal in construction upon railroads, and especially the construction of the great iron bridges, Conway and Menai, were the occasion of new experiments, very numerous and interesting. The account of these observations, generally extended to the point of rupture, is contained in the monograms upon the construction of these great bridges of Stephenson.

All these results have led to more exact determinations of the specific constants relative to iron. They show that iron obeys the theoretic laws of transverse flexion for slight deformations; that the coefficient of elasticity is reduced in very large works; that the resistance of iron to crushing is generally less than the tensile resistance. The reverse is true of steel. Besides, the limit of elasticity of steel is greater for compression than for tension; while in wood and iron the limits are the same. The coefficient of elasticity for steel is not the same for compression as for extension—a singular anomaly, which makes rigorous calculation of flexion very difficult. MM. Collet-Meygret and Desplaces have deduced an interesting consequence from observations made on the Viaduc de Tarascon; it is, that in steel the sections do not show everywhere an equal elasticity, so that it is necessary to distinguish the shell from the portions near the surface, giving to each its special coefficient. The line of demarcation between the two regions seemed to be difficult to trace rigorously. Iron drawn into wire of a small diameter

presents analogous phenomena; so that it has long been known that iron wires contain elements that resist extension—a property utilized in the construction of suspension bridges.

Hodgkinson has made a special study of the resistance of pieces under pressure at their abuttings; among these, upon steel columns. His empirical formulas give the breaking load of a hollow column in terms of its height, and its external and internal diameters. The load which a column can safely bear is fixed at a sixth of the breaking load given by the formula. He has shown by numerous experiments the influence of the shape of the base, whether flat or round; and also the effect of renflement. He has substituted a formula for wood instead of that given by Rondelet, and shows that the load supported by oak varies nearly as the fourth power of the least dimension divided by the square of the length. M. Sove has substituted more convenient formulas for solid columns of steel or iron; they lead without difficulty to the choice between iron and steel for a column of given dimensions.

The observation of the vibratory motion of elastic solids leads to the determination of the coefficients of elasticity. It is the only method applicable to their plates or to wires. To this class of researches belong the experiments of Wertheim, and those of M. Phillips upon the spiral réglant.

In a scientific point of view the experiments upon the resistance of materials have shown that the hypotheses assumed in the solution of the problem of the deflexion of beams cannot be regarded as absolutely true. It is almost impossible to determine the limit of elasticity. A metallic bar, once subjected to tension, does not return to precisely its original form when the tension ceases, and its elasticity has undergone a certain alteration. The limit of elasticity, as understood in practice, is that limit at which alteration becomes sensible by the coarse methods of experiment; but as these become more precise, it is seen that this limit gradually diminishes, and it would without doubt disappear if the processes were perfect. The limit of elasticity is certainly of great importance; but one should not pretend to determine it with a precision that cannot be applied in a practical problem. Late experiments have shown the existence of certain lacunæ in the theory, without filling them. They have shown the great complexity of the problems without suggesting the means of getting rid of it; so that the old theory of deflexion remains the only guide that can be confidently followed, while we wait for the perfect solution which is to come from future investigations.

BLAST FURNACE ECONOMY.

From "Engineering."

At the general meeting of the Institution of Mechanical Engineers, held on Thursday, 28th April, in the Lecture Theatre of the Midland Institute, Birmingham, John Ramsbottom, Esq., President, in the chair, after the Secretary (Mr. W. P. Marshall) had read the minutes of the previous meeting, and a number of new members had been elected, the adjourned discussion was resumed upon the paper read at the previous meeting, "On the Further Economy of Fuel in Blast Furnaces, derivable from the High Temperature of Blast obtained with Cowper's Improved Regenerative Stoves at Ormesby, and from Increased Capacity of Furnace," etc., by Mr. Charles Cochrane, of Dudley. The improved regenerative hot-blast stoves at the Ormesby Ironworks, Middlesbrough, are heated entirely by the waste gas taken off from the blast furnaces; and the heat developed by the combustion of the gas is stored up in the stoves by means of the "regenerator," consisting of a large mass of open-built fire-brick, through which the heated current is made to pass in a downward direction on its way to the chimney. The mass of fire-brick thus becomes heated up to a very high temperature at the top, the temperature gradually diminishing towards the bottom of the regenerator; and the blast, being then caused to pass through the regenerator in the contrary direction, takes up the heat stored in the fire-brick, and becomes itself heated to the same high

temperature previous to entering the blast furnace. In the present stoves, which are of considerably larger dimensions than the original stoves on the regenerative plan at these works, the combustion chamber at the top of the stove has been increased in proportionate capacity, in order to insure, as far as possible, the complete combustion of the gas in the stove before entering the regenerator; the area of all the passages has also been enlarged, and the fire-bricks in the regenerators are set wider apart. A recent improvement has been made in the construction of the regenerators, which avoids the necessity previously existing for the use of a purifier to separate the dust brought over with the gas from the blast furnace, for the purpose of preventing the passages in the regenerator from becoming gradually choked up by the accumulation of this dust. In the improved construction the successive courses of the fire-bricks are so arranged that the edges of the bricks in each alternate course project a short distance beyond the edges of those in the courses immediately above and below; and the regenerator is thus made up of a collection of vertical flues, the internal surfaces of which are broken by a number of projecting ledges, whereby the interchange of heat between the mass of brickwork and the currents passing through it is very completely effected. At the same time a clear straight passage is left from top to bottom of each flue, large enough to admit of cleaning out the dust deposited upon the faces of the brickwork, either by the insertion of a brush or by the use of a jet of blast, without the necessity of removing any of the bricks for the purpose. In consequence of these improvements in the regenerative stoves, the blast heated by them is now maintained in regular working at the high temperature of more than 1,400 deg. Fahr.; and although the annual expenses for cost and maintenance of the regenerative stoves are about the same as those of the most improved cast-iron stoves heating the blast to about 1000 deg. Fahr., the economy of fuel in the blast furnace consequent upon the higher temperature of blast, is found, from the experience of actual working, to amount to as much as 4 cwt. of coke per ton of iron made. The amount of economy of fuel, however, that is due to equal increments of temperature in the blast, has been found by the experience of the temperatures already reached in practice to diminish rapidly as the temperature is raised; and it is therefore considered by the writer that the further saving of coke in the blast furnace for a still further increase in temperature of blast from 1,400 deg. to 1,700 deg. would be less than 1 cwt. per ton of iron. With regard to the capacity of blast furnaces as affecting the economy of fuel by diminishing the temperature of the escaping gas, the actual result now obtained at the Ormesby Ironworks, with a furnace of 20,000 cubic ft. capacity, is a consumption of 20 cwt. of coke per ton of iron, with the blast heated to upwards of 1,400 deg., and with calcined ironstone yielding 40 per cent. of iron; and assuming that the same reduction of temperature which has been effected in the waste heat escaping from the regenerative stoves by doubling their capacity would also be effected in the waste gas escaping from the blast furnace by doubling the capacity of the furnace, it would follow that by doubling the capacity of the present large furnaces of 20,000 cubic ft. the further economy of fuel consequent upon reduction of heat in the escaping gas would be about 2 cwt. of coke per ton of iron made. In reference to the effect of increased heat of blast upon the temperature of the escaping gas at the furnace top, the working of two similar furnaces of 20,000 cubic ft. capacity each, has shown that neither extra heat of blast nor extra driving has any prejudicial effect on the temperature of the escaping gas; and that the extra heat thrown into the furnace by the hotter blast is met by the extra duty to be performed in compensating for the diminished proportion of coke consumed per ton of iron made.

A description was then given of the Regenerative Hot-Blast Stoves employed at the Consett Ironworks, Durham, by Mr. Thomas Whitwell, of Thornaby, Stockton-on-Tees. These stoves are constructed with a series of transverse vertical walls of fire-brick with narrow spaces left between, forming the regenerator, in which openings are made alternately at the top and at the bottom of the successive walls for the passage of the current. The waste gas from the blast furnace being mixed with air and ignited in a combustion chamber at one side of the stove, the

heated current passes alternately upwards and downwards through the successive spaces left between the series of tranverse walls, depositing its heat in the brickwork, and reaching the chimney valves on the opposite side of the stove at a low temperature. The regenerator thus becomes highly heated on the side of the combustion chamber, but remains cool on the chimney side; and the blast being afterwards passed through it in the contrary direction, takes up the heat from the successive fire-brick walls, and becomes itself heated to the same high temperature previous to entering the blast furnace. Cleaning doors are provided in the roof of the stove, through which scrapers are inserted for scraping off the dust deposited upon the surface of the walls; and the dust scraped off is raked out through side doors at the bottom of the stove. By this means the gas dust is easily removed in a very short time, the cleaning being effected entirely from the outside, whilst the stove continues hot, without requiring to be cooled down at all for the purpose; and a small pair of these stoves at the Thornaby Ironworks have been at work for several years without requiring any cleansing of the gas prior to its use in the stoves. The saving of coke in the blast furnace, consequent upon the use of the blast supplied by these stoves at the temperature of 1,400 deg. Fahr., has been found at the Consett Ironworks, where several of the stoves have been a year at work, to amount to 5 cwt. of coke per ton of iron made, in comparison with the consumption required in a furnace supplied with blast at 850 deg. by cast-iron stoves; and the actual consumption with the blast at 1,400 deg. temperature is less than 18 cwt. of coke per ton of iron, in a furnace making 400 tons per week, and burdened with a mixture of Cleveland and hematite ironstone yielding 48 per cent. of iron.

PARKER'S STEAM AND AIR ENGINE.

From "The Engineer."

Two inventions now claiming public attention possess no small amount of interest for employers of steam-engines. The inventors of both propose to increase the power to be obtained from the combustion of a given weight of fuel by working air expanded by heat in conjunction with steam. The first of these inventions, in point of date, is Parker's steam and air engine; the second is Warsop's aero-steam engine. The general principles involved are, up to a certain point, the same in both motors; but the method of applying these principles in practice differ widely. We have not as yet had any opportunity of personally examining and testing a Warsop engine, and we are, therefore, unwilling to say anything about it. At some future day, when a test engine now being constructed by Messrs. Easton and Amos, for Mr. Warsop, is complete, we hope to say something more on the subject. For the present, we shall confine our attention to Mr. Parker's invention, which we tested practically for some hours on Tuesday last, with results which we shall now proceed to place before our readers; premising that in the Warsop engine air is forced by a suitable pump through a coil of pipes exposed to a high temperature, into the water contained in any boiler that may be employed —Cornish, marine, or locomotive—the air on entering being in all cases much hotter than the water. In Parker's engine, on the contrary, the air is forced directly into the steam pipe leading to the cylinders, and, therefore, cannot have a higher temperature than that of the steam with which it is in contact.

The engine which we examined stands in the yard of Messrs. Yarrow & Hedley, Isle of Dogs, and is driven by one of the small boilers used by the firm in propelling steam launches, for the construction of which they enjoy an excellent reputation. This boiler contains an internal fire-box, communicating with a smoke-box by 47 vertical tubes 8 in. long. The total heating surface is 22 square ft., of which 11 ft. are in the tubes. The engine is an old launch engine of an antiquated pattern, with 2 cylinders 5 in. diameter and 6 in. stroke, horizontal, with a fly-wheel exactly 14 ft. in circumference hung on the shaft between the 2 cranks. Two steam pipes place the boiler in communication with the cylinders; one leads directly to them

in the ordinary way, the other is fitted with Mr. Parker's apparatus, which we are about to describe. The effect of the arrangement is that the engine can be run either with steam only, or with steam and air. Mr. Parker's apparatus consists of a vertical steam pipe, A, in the accompanying rough sketch, and a vertical "air" pipe, as it is called for want of a better name, B. This last communicates with A by means of 4 small nozzles, D, of brass, each having an orifice of $\frac{1}{8}$ in. diameter. The nozzles are surrounded each by a small tube, pierced with holes, through which the air is drawn by the inductive action of the steam passing from B to A. We append an elevation and section, full size, of one nozzle. The construction is very peculiar, but we cannot stop now to explain why these peculiarities are present. A cock is fitted on the engine to regulate the pressure of steam and air in the pipe A, and another is fitted between the boiler and B to regulate the pressure in the latter. It will be understood that all the steam used in driving the engine must find its way through the nozzles, which are to all intents and purposes open to the atmosphere. The pipe A is 1 in. in diameter inside, and passes through a small coke fire C; this fire is, however, in no way essential to the utility of the apparatus. Our readers are now, we think, in a position to understand what follows.

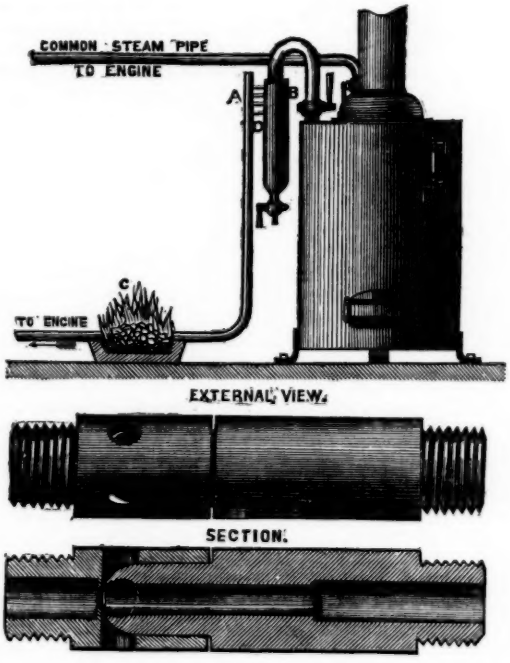
We carried out two trials on Tuesday. The first was intended to determine the quantity of coal used during a given amount of work done with steam only. The second was intended to decide the same point when air and steam were used together. In order that the principle might be fairly tested, the boiler, engine, and load were precisely the same in both trials. The fly-wheel was fitted with an ordinary belt-and-block brake, carrying a load of 30.5 lbs. The engine was fitted with a counter. Steam was first raised to 60 lbs. pressure. The fire was then drawn, only enough being left to light the fresh coal then supplied. The quantity of coal allowed for each trial was half a cwt. The engine was started, and run against the brake at as nearly as possible 90 revolutions per min. When all the coal was used, and the pressure began to fall, the speed of the engine was carefully noted, and as soon as it fell below 80 revolutions the engine was stopped, and the running time and number of revolutions noted; the water was left at the same height in the gauge as at the beginning of the experiment. Sufficient fuel was then put on the fire to raise the steam once more to 60 lbs. The fire was then drawn, and firing commenced with the second half cwt. of coal, and a run made with the new system in precisely the same way. As soon as the speed fell below 80 revolutions the engine was stopped, and the number of revolutions and the running time noted. We have arranged the results for convenience in the following table:

Steam Only.

Started.	Stopped.	Running Time.	Total Number of Revolutions.	Average do.	Total work done, in foot-pounds.	Actual H. P.
h. m. 2.50	h. m. 3.45	h. m. 0.55	4,827	87.763	2,061,129	1.135
		Steam and Air.				
h. m. 4.3	h. m. 5.31	h. m. 1.28	8,071	91.715	3,446,317	1.186

It will be seen that we have here taken no account of the coke used in the little superheating fire C.; nor is it, we think, necessary that we should. The length of pipe in the fire was just 15 in.; the total superheating surface about 50 in. only. It was certainly not more efficient than the addition of 100 sq. in. of tube surface to the boiler; or, in other words, the addition of $\frac{1}{31\frac{1}{68}}$ to the heating surface of the boiler, an augmentation which bears an infinitesimal proportion to the total amount gained by the use of the induced air. Mr. Parker assures us, however, that from the use of the superheating surface an amount of economy results which

appears to us to be totally inconsistent with the smallness of the surface ; in no case can it account for the foregoing saving of 70 per cent. in fuel. The objection which will be urged by many engineers to the system is, that, although the results of its application are so satisfactory in the use of a very bad engine, they will not hold good of a better engine. What, it will be said, can be thought of an engine burning 56 lbs. of coal, or thereabouts, per horse per hour ? But it must not be forgotten that the fault lies as much with the boiler as the engine. Careful experiments made by Mr. Parker during the last 6 years show that, under the conditions, each $\frac{1}{8}$ in. jet will pass about 30 lbs. of steam per hour ; that is to say, for the 4 jets, 120 lbs. of steam. We did not measure the water used, but judging by this estimate of Mr. Parker's, and the number of buckets of water actually pumped into the boiler by hand during the trials, we are inclined to believe that the boiler does not evaporate much over 3 lbs. of water per pound of coal burned. But Mr. Parker's



system has nothing whatever to do with the defects or merits of the boiler. If the boiler were better, the economy of fuel would be increased precisely in the same ratio. As regards the engine, it possessed precisely the same qualifications for using steam to advantage as it did for using steam and air combined. It is unnecessary here to go into an elaborate investigation of the reason why the use of air, as proposed by Mr. Parker, must be attended with advantage ; that is a subject which we must reserve for another article. Dealing with the thing for the moment in a purely practical way, we may point out that the engine is a meter, measuring more or less exactly the quantity of fluid passing through it per min. or per hour. If the source of supply is the boiler alone, then all the fluid passing through must be supplied by the boiler ; but if steam and air pass through together, as the cylinders will only pass a given quantity of the combined fluids in a given time, then the demands made on the boiler for steam will be reduced by just the amount of air

which takes the place of steam. In other words, if the engine working steam alone used 120 lbs. per hour, and, when using half steam and half air, still passed only 120 lbs. of the combined fluids, then, roughly speaking, it would only pass 60 lbs. of steam—as the weight of steam and of air is not the same, volume for volume; this statement requires correction, but, being used merely to illustrate a principle, it is sufficiently accurate. It may be urged that the steam does work in taking in the air, which is true; but it is also true that, bating the friction in the nozzles, no work is done on the air which it is not placed in a position to return in the form of duty done on the air which is not placed in a position to return in the form of duty done on the pistons. By far the larger portion of the work done by the steam is expended in raising the temperature of the air; but seeing that the specific heat of air is only about half that of steam, and that air expands 1-490th for each increment of 1 deg. Fahr. of heat, it is evident that the steam does this work at considerable advantage; probably to far greater advantage than it can do any other work whatever on extraneous matter.

The working pressure of the steam *in the cylinders* was about 16 lbs. on the sq. in., both with and without the air jets. When steam alone was used it was impossible to maintain a pressure of 60 lbs. in the boiler with any larger opening of the stopcock regulator than that giving a speed of about 87 revolutions per min., which corresponded with a cylinder pressure of about 15 lbs. If the stopcock was opened further the pressure fell. The pressure of the induced current—in other words, that within A—was 15 lbs., while at the other end of the pipe next the engine it was 16 lbs. to 17 lbs., as shown by 2 gauges corresponding with each other. The true objection to the Parker system is that the engine pressure cannot be *economically* made to exceed about one-third of the boiler pressure. But, on the other hand, it is claimed for the system, and we think with justice, that the average pressure throughout the stroke will always be higher with any given amount of cut off than it practically is when steam alone is used. The reason why is sufficiently obvious. Steam is condensed and loses its pressure with frightful rapidity when in contact with a cold surface, whereas air under the same circumstances parts with its heat with extreme sluggishness as compared with steam. Thus the expansion curves of diagrams taken with steam and air combined passing through the engine are always much higher than when steam alone is used; from this it follows that a given area of piston is more effective with steam and air than with steam only. If, then, low pressures are to be used in non-condensing engines, we must do either of two things—use larger cylinders, or higher speed to obtain the same power. But then if we use high measures of expansion with steam alone we must have large cylinders; and it is maintained for the Parker system that using a boiler pressure of 100 lbs., we can have an initial cylinder pressure of 35 lbs., which, cut off at half stroke, will give an average pressure of 29 lbs. or thereabouts; while if steam alone be used of 100 lbs. pressure, it must be expanded some 7 or 8 times to prove equally economical, and with this measure of expansion the actual average pressure in practice will not exceed 30 lbs. or thereabouts. In confirmation of this theory, we may cite the case of an engine from which we have taken numerous diagrams; with a boiler pressure of 50 lbs., cut off at rather more than half stroke, the average pressure ought to be 42.3 lbs. per sq. in. It is actually, according to the diagrams, 22.9 lbs.; and this is a well-made engine, working up to 110-horse power, with the cylinder and steam pipes carefully lagged, and the pressure in the valve chest within 3 lbs. of that in the boiler.

Of course, if this theory hold good, the great advantage of the Parker system would lie in the fact that expanding a mixture of air and steam onefold in a given cylinder, the consumption of fuel will be the same as though steam alone of the same initial pressure were expanded seven or eight fold. We should at one stroke thereby get rid of all the evils proper to irregular driving force. Precisely how far the theory which we have thus sketched may or may not correspond with the results of practical trials on a large scale we are unable, of course, to say; but it is indisputable that we have obtained results from the Parker system more satisfactory than any we have ever

obtained, or known to be obtained under similar circumstances, from other improvements in the steam-engine, and it must not be forgotten that these results have been secured by the aid of one of the simplest and most inexpensive devices which it is possible to conceive; the entire cost of a Parker apparatus for an engine of moderate size probably not exceeding £10 or £15 sterling.

BRIDGE CONSTRUCTION.

By Col. W. E. MERRILL, U. S. A.

There are some points in the review of my recent work* on "Truss Bridges," published in the "Journal of the Franklin Institute" for February, 1870, which I think demand reply, and as the reviewer has, in some points, misunderstood the object of my work, and my reason for going into certain elaborations, which I agree with him in considering unnecessary in practical construction, I am glad to be able to avail myself of the opportunity for restating my object and views.

My object was not in any way to deal with the details of making the parts of a bridge, which pertain rather to mechanical than to civil engineering, but simply to discuss the problem of *form*—to endeavor to ascertain, by calculation, *which* method of combining chords, posts and braces would give the best results—or, in other words, would necessitate the use of the least amount of iron to carry with a given degree of safety a given moving load. To do this it became necessary to take each well-known form of bridge and calculate the weight of each one of its parts with the utmost nicety, assuming for each one of the trusses examined the same permanent and rolling load, and the same general dimensions.

To do this, with justice to all, I was necessarily led into many refinements of calculation which in ordinary cases are entirely unnecessary; such as the "extra strains," and for some spans, the subdivision of the rolling load.

It is well known that when a long pillar is loaded with a weight acting through its axis, it breaks by flexure, under a strain much less than the crushing weight of its cross section. It commences to bend under a still smaller weight. The moment this begins it becomes, as it were, two pillars making a very obtuse angle with each other, held together by molecular cohesion. Every pound of additional weight gives necessarily a transverse component at the point of flexure, as well as a component through the lower half of the pillar, neutralized by its support. Manifestly, if we can hold the pillar in any manner at the point of flexure so as to neutralize this transverse component, and prevent it from acting on the pillar, we very greatly increase its capacity to withstand a strain through its axis. If this pillar were composed of a number of small pillars fastened together, no matter in what way, this tendency to flexure would still exist. But the top chord of a bridge, with the strains through its axis, presents an analogous case, with the additional unfavorable transverse action of its own weight. The chord, therefore, must naturally sag somewhat; and no matter how carefully the mechanical connections are made, as it is impossible to keep the segments in a strictly accurate line, there must be generated transverse strains at the joints of the series. If this were not the case, why is it necessary to have top lateral bracing? Parallelism of the trusses could be secured by connecting the end posts, were there not deflecting agencies to be guarded against at other points. Universal practice in construction recognizes the existence of these abnormal horizontal strains. It seems, therefore, an inevitable conclusion that the abnormal vertical strains should be recognized also. How to estimate for them is a different matter, and, after long and patient study and investigation, I could decide upon no better or simpler method than that given in the text.

Experience has shown that in the Bollman bridges it is absolutely necessary to introduce panel posts and ties which form no part of the weight-bearing system. The theory which I have adopted ac-

* "Iron Truss Bridges for Railroads," by Brevet Col. Wm. E. Merrill. Published by D. Van Nostrand.

counts for their use and necessity, and gives an approximate means of estimating their sizes. Knowing them to be essential in this bridge, I was necessarily led to examine into the need of something similar in other bridges. The calculations show that in most others these "extra strains" are, in the main, provided for by the ordinary posts and braces. But, as a matter of justice to all, I was compelled to take these strains into account wherever they added even a pound to the maximum direct strains on any principal member. Though I admit freely that in most cases such a discussion is an unnecessary refinement, I yet must insist that in a *comparison* as to economy in combination it is imperative to take everything into account that can effect the result. I thought that my opinions and reasons on this matter were all set forth with sufficient clearness in the work itself, but as the reviewer seems to have failed to appreciate my argument I hope that this explanation may be of service to him As to the size of top chord selected for computing these extra strains, I am aware that I exaggerated somewhat, but I considered it best to do so in order to provide fully for shocks and vibrations that cannot be brought down to exact calculation.

The "mathematical jugglery" referred to in the review is simply the necessary transposition of terms in Hodgkinson's formulæ in order to obtain, in the shortest time and simplest manner, the values of the *diameter*, which in bridge calculations is necessarily the unknown term. Hodgkinson's formulæ only show how to find the breaking weights of *given* pillars; but in bridges this breaking weight, which is the maximum strain increased by the factor of safety, is a *known* term, as is also the length. It is, therefore, an absolute necessity that the equations be solved with reference to d, the unknown term and quantity sought. In the case of short pillars the difficulty in obtaining d is still further increased by the use of his formulæ. It is true that when d is given and W is sought these formulæ are of easy application, but when the reverse is the case, d can only be obtained by a series of approximations, unless the equations are combined and a single equation deduced for the value of d. This simple and necessary work seems to have bewildered the reviewer, and, therefore, he contemptuously styles it "jugglery." This is certainly a strange term to use in a serious review of a professedly mathematical work.

The reason why I made use of the round-end formula in calculating compression strains is fully stated in the work. According to Hodgkinson the strength of a flat-end pillar, not immovably fixed, is about one-third of what it is when the ends are so secured that no motion whatever can take place. Posts and Top Chords in bridges, however accurately the connections are made, are subject to vibrations and small movements, and therefore are not proper cases for the use of the flat-end formula. It is a matter of choice whether we should use the flat-end formula, divided by three, or adopt the round-end one, which gives exactly the same result. Bearing in mind that my object was only to institute a comparison for the purpose of ascertaining the merits of the different combinations, it seemed immaterial which course I had better follow, and therefore I choose the one that seemed simplest—using the same formula in all cases.

I am quite willing to concede that "ordinary engineering calculations do not require astronomical accuracy," but the reviewer should have borne in mind that I was not making an ordinary engineering calculation, but a *comparison*, and therefore was compelled to take everything into account that could effect the result. I have used logarithms freely in order to insure accuracy, and because Hodgkinson's formulæ cannot be used without them ; and I cannot believe that any good engineer can afford to neglect so great an assistance, or can find any difficulty in its use. At all events railroad engineers, who are daily using logarithmic sines and tangents, can hardly object to logarithms of numbers. I have been very careful in the tables to give both the actual numbers and the logarithms of all constants, in order to facilitate as much as possible the use of the formulæ.

The nomenclature of the trusses examined is but a small matter at best. It was necessary to name them for convenience of reference, and I used my best judgment in choosing the designations adopted. If I have, unintentionally, done injustice to any bridge builder I regret it ; but as the

trusses themselves are carefully drawn in outline, those disliking the titles which I have chosen may give them such others as may seem to them more fitting.

I am aware that the Fink and Bollman bridges are better as deck than as through bridges, and I have so stated ; but as from necessity the great majority of railroad bridges are overgrade I did not deem it necessary to make a special discussion of undergrade bridges.

The only really important objection that the reviewer has advanced is that to my manner of treating the counter. But while he objects to my conclusions, and quietly states that there can be no question as to the true use and action of this member, he neither refers to the proofs which I have alleged in favor of my view, nor gives any himself. I am fully aware that many high authorities on bridge building are on his side, but the assumption that *all* are, and that there is but one opinion on the point involved, is gratuitous and inaccurate. The point is *not* a conceded one, and if it were, he should have been able to point out the error in the course of reasoning by which I apparently proved the contrary. I have endeavored to prove every step which I have taken, and also to express these proofs so clearly that no one could misapprehend my meaning. The natural inference is, that the reviewer could not successfully attack my demonstrations, or else that he examined the book so carelessly as not to have noticed them.

In reference to the use of cast-iron for compression, I have simply expressed my individual preference. The strongest reason for my choice of it in making the comparison as to economy in combination, arose simply from the fact that cast-iron compression members can more readily be calculated from formulæ than similar parts of wrought-iron. The latter depend for strength so much on mechanical skill and peculiarity of combination, that the only sure dependence on them comes from experiment. I doubt if a formula could be found that could give, with any reliability, the comparative strengths of the different posts and chords in use. Moreover, the object of the treatise was not to discover which bridge-building company had succeeded in getting the best posts and chords to sustain given strains, but to ascertain which would have the least strains to meet, and which, therefore, ought to be able, with a given amount of metal, to make the strongest bridge. The test of this point simply required perfect conditions of equality—and, it was believed, that such equality could best be secured by assuming cast-iron compressive members. The reviewer refers, occasionally, to Mr. Shale Smith's pamphlet, in terms of commendation. If he will examine it carefully, he will there find that Mr. Smith has spoken much more decidedly of cast-iron than I have.

The competition for the Quincy bridge is adduced as showing, from the builders themselves, a different estimate of weights from that which I have deduced. This is begging the question, as there is nothing to show that the three bridges had the same strength. The bidders may have overestimated or underestimated the strains which they were to provide for. The comparative statement is of no value at all unless it be shown conclusively from calculations made by the same engineer, that the three bridges were equally strong throughout. Comparing the bids with my own calculations for the same span, I can only conclude that Mr. Post would have built the strongest bridge.

Finally, I would like to add a few words about the object and purpose of my work. I do not claim it to be exactly correct, but simply that it is correctly reasoned to the best of my ability. Bridge-building, as a science, has improved greatly within the last few years, and it is to be presumed that it will continue to improve. Until it reaches perfection it is the bounden duty of all engineers to contribute what they can to clear up any dark points. By combining the studies and knowledge of many, some clearing up one obscure point and some another, though no one author may be right throughout, yet those that come after can gather up the scattered truths and build up a harmonious and correct system. Believing this, I have given my little work to the world, not as finally conclusive on the subject of truss bridges, but simply as my individual contribution. That it would meet with hostile criticism I expected, but I hardly looked for so *ex-parte* and thoroughly prejudiced a review as that which has called forth this reply. The best points in the work are quietly ignored and much ado is made about preface and bridge titles, things in them-

selves of little importance, and of no bearing on the general result. I gladly invite criticism, and hope that much good, to myself and others, may arise from the full discussion of the points at issue; but I hope that the next reviewer may come to his task without a mind as evidently made up in advance, and so determined to see nothing good in the work. I have prepared this answer to the reviewer more because of the influence and character of the journal in which his critique appears, than on account of anything in the article itself.

THE TORSION OF CRANK SHAFTS.

From "The Mechanics' Magazine."

In any ordinary type of steam-engine without a rocking shaft, the only portion of its mechanism subjected to torsional strains is the crank shaft, and it may not be out of place if we consider their nature and magnitude. Some authors would appear to consider them as being alike uniform, whether the steam be worked to a high degree of expansion or not. Such a supposition is, however, an erroneous one, as we can soon show. Evidently the torsion on the shaft is proportionate to the speed of the piston—we will assume but one for the sake of simplicity. Let us first take the crank at the dead centre; it is clear that whatever the pressure on the piston now, there is no twisting strain whatever on the shaft, because the piston is absolutely motionless, and without motion or the tendency to move if at liberty, there can be no strain. We may now move the piston to the point it would occupy with the crank at right angles to the axis of the cylinder; here the piston, if the engine were running, would have its maximum speed, and consequently, were it not for the loss due to the obliquity of the connecting rod, the torsion of the shaft would likewise be greatest, if the steam were not cut off before the half stroke; or, to bring the question to analysis, the calculation with the crank at the dead centre, and assuming a 6 in. cylinder and 12 in. stroke, with 50 lbs. steam, would give a pull on the piston rod of, say for simplicity, 28¼ square inches by 50 or 1,412.5 lbs., but there would be no torsion on the shaft till the connecting rod formed an angle with the piston rod. When the crank was at an angle of 45 deg., then the twist on the shaft would equal the length of the semichord of the arc described by the crank pin, that being the actual length of the leverage of the crank when in that particular position. The length of this semichord in the example we have taken would equal the sine of the angle formed by the crank with the horizon or =4.24, therefore the torsion here would equal, if there were no expansion of steam, 1,412.5 × 4.24=5,989.000 lbs. If now, we suppose the steam cut off at $\frac{1}{1\frac{1}{2}}$ of the stroke, then, when the piston arrived at the position due to the crank being at the 45-deg. angle, it would be 1.76 units from the end, neglecting clearance, and the steam pressure would be then diminished, according to Marriotte's law, from 50 lbs. per square unit to a pressure found by dividing 50 by 1.76=28.4, and, consequently, the torsion on the shaft then would equal the sine of the crank's angle, multiplied by 28.25 × 28.4, or=802 lbs.×4.24=3,400.48 lbs. In all calculations, therefore, of the strength of crank shafts, the measure of expansion must ever form a factor. The formulæ may be stated thus:—S=sine of the crank angle with centre line of cylinder, P= actual pressure on piston per inch at that point of the stroke, A=area of piston. Then S.P.A=T. T=torsion of shaft, neglecting the angle of connecting rod.

Of the passengers killed in 1869, 12 lost their lives by collisions of trains, 4 by part of the train getting off the rails, 1 (a child) was killed by the carriage door on the off side giving way when she was leaning against it, 12 by alighting from or attempting to enter a train in motion, 1 (a child) by falling out of a train in motion owing to want of care on the part of his parents, 6 by incautiously crossing the line at a station, 2 run over at stations through their own want of caution, and 1 was killed by "incautiously looking out of a window when near a station, his head coming in contact with a bridge only 13½ in. from the window."

RECENT EXPERIMENTS ON THE STRENGTH OF CANNON POWDER.

From "The Engineer."

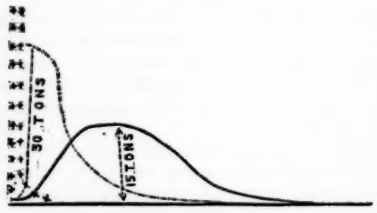
It has long been known to artillerists that the strength of gunpowder is conditionally variable, the conditions of variation being the quality of the ingredients, the proportions in which they are used, the methods of manufacture employed, the form in which the powder is burned, the system of ignition, and the weight of the charge. It is proper to add that the word "strength," when employed in speaking of gunpowder, admits of two interpretations. It may either be used roughly to define the strain exerted on the gun, or the force of expulsion exerted on the shot. Gunpowder may be strong in either or both of these senses. Thus a powder may be produced which will strain a gun excessively, while doing little work upon the projectile; or, on the other hand, one which will strain the gun very little by comparison, yet impress a very high initial velocity on the shot. Up to a comparatively recent period, nothing more than is contained in the preceding statement was known. Even at the present day much remains to be done in the way of formulizing the effects produced by powder of different qualities burned under varying conditions. Piobert, Dalghren, Mallet, and Lynall Thomas have been the principal laborers in this interesting field of research. The results of ordinary practice, of experiments conducted in America and France, and other causes, induced our Government to take the matter up and conduct an experimental inquiry of an elaborate character, intended to settle: (1) The amount of pressure developed in the bore of rifled and smooth-bored guns of different calibres, by the employment of charges of gunpowder of different descriptions, and the law it follows. (2) The comparative merits of every variety of service gunpowder, and of any foreign gunpowders which might be procurable for trial. (3) The effect of igniting the charge at different points. (4) The effect of the length of the bore of the gun on the velocity of the shot at the muzzle. (5) The comparative merits of gun cotton in the smaller calibres. (6) The comparative merits of other explosive agents. It was anticipated that the result of the inquiry would settle what is and what is not the best powder for very heavy ordnance; as regards small guns, the inquiry possesses second-rate importance. To carry it out, a committee was appointed in May, 1869, consisting of Colonel Younghusband., R.A., Superintendent of the Royal Gunpowder Factory; Captain Andrew Noble, late R.A.; Captain W. H. Noble, R.A.; Mr. F. A. Abel, F.R.S.; and Captain Molony, R.A. The preliminary report of this committee has just been issued. Its importance demands immediate notice at our hands, but it must be borne in mind that few details of the actual experiments are given; we think it better, therefore, at present to deal only with the substantial results obtained, reserving the experiments for future consideration when we have been placed in full possession of all the particulars.

Fifteen different kinds of powder have been tried, but the report before us deals only with 4 of them, which are R. L. G. service powder, 1867 pattern, and a new powder known as pebble powder No. 5. The following tabular statement shows the results obtained:

Nature of Powder.	Charge.	Muzzle Velocity.	Maximum Pressure.
	Lb.	Feet per Second.	Tons per Square Inch.
R. L. G. service.	30	1,324	29.8
Russian prismatic	32	1,366	20.5
Pellet service.....	30	1,338	17.4
Pebble No. 5.....	35	1,374	15.4

It will be seen at a glance that pebble powder promises to do more to aid us in the use of very heavy guns than any other modern invention. While ordinary large-grained powder imposed a strain of nearly 30 tons on the square inch of the gun, and yet imparted to the shot a velocity of but 1,324 ft. per second, pebble powder expelled the projectile with a velocity of 1,374 ft., and, in spite of the extra weight of the charge, only strained the gun with a pressure of 15.4 tons per

square inch. In other words, a gun burning pebble powder should last about four times as long as a similar gun burning L. G. powder. We say four times, because the damage done to a gun increases probably in even a more rapid ratio than the square of the strain upon it, even between such limits as 15 and 20 tons to the square inch. It is impossible to overestimate the importance of the foregoing results. Whether they will be confirmed in the case of heavier guns than that actually used in the experiments—one of 8 in. calibre, smooth-bore, firing 180 lbs. cylinder of iron—remains to be seen, as does the effect of rifling, windage, and numerous other points with which no doubt the final report of the committee will deal with exhaustively. A few trials which have been fired in a 10 in. gun are eminently encouraging.



It will be asked how it is possible that powder only exerting a propulsive strain of 15 tons per inch can drive a shot out of a gun with the same velocity as powder exerting twice the force? Mathematics would be out of place at the moment. It must suffice to explain that the action of the 15-ton powder, if we may so classify it, is prolonged over a greater period than that of the 30-ton powder. In the second place, less work is done in compressing the particles composing the shot and expanding the bore of the gun; in consequence, more effective work is done on the shot. This of course follows on the fact that pebble burns more slowly than rifle powder. It appears also that before the great bulk of the charge is ignited the shot has been started into rapid motion. The relative action of the two powders may be conveyed to the mind of the reader by the accompanying diagram, which it will be understood is only intended very roughly to illustrate the phenomena, not to formulize them. The dotted line denotes the action of rifle, and the full line that of pebble powder. The areas included between the respective curves and the base line show the work done in propelling the shot, but the vertical heights of the curves above the base show the strain thrown upon the gun, which may be independent of the areas altogether, as in the case of gun cotton which would probably give a curve similar in character to that shown by the line * * * * * * Copies of the diagrams, actually obtained in the course of the experiments, we hope to place before our readers in due time.

A very able investigation of the mutual relations of the material of a gun, and of the rapidity of explosion of the charge, will be found in "Mallet on the Construction of Artillery," page 127. We cannot better conclude this article than with a quotation from Mr. Mallet: "The researches of Piobert have shown that, as a determinable time is necessary before the inertia and compressibility of the shot can admit of sensible motion, so this maximum pressure is greatly increased, and the maximum more rapidly reached from the first instant of ignition, in proportion as the powder is of a quality to burn more rapidly; so that, carried to its extreme limit, as in the firing of some of the fulminating compounds, the gun is burst before the shot is sensibly moved, and the velocity attained by the latter is very slight."

The undertaking of the Indian Tramway Company, from Arconum to Conjeveram, about 19 miles in length, is incorporated in the Carnatic Company, and it is intended to extend that line to about five principal places in its route to Cuddalore. The extension line will be about 120 miles in length, and pass through a populous and fertile country. The exact route will be determined by the Madras Government. They will have to cross one large river and a smaller one. There may be a branch from the railway to Pondicherry, as the traffic there will be large.

The telegraph wires upon the line from Limerick to Ennis were maliciously cut near Clare Castle on Monday. The object of this malicious act is not known, and no arrest has as yet been made.

WIRE TRAMWAYS.

Condensed from "Scientific Opinion."

In the spring of 1869 Mr. Charles Hodgson, C.E., patented and published his method of Wire Tramways. The single trial line then constructed at Leicester so satisfactorily exemplified the inventor's method, that in the short space of 12 months more than a dozen lines have been constructed, and 14 are in course of erection in various parts of the world, the system having found especial favor in France where 7 lines are made use of in the carriage of beet-root, and so successfully, that the lessees of the patent are desirous of not only possessing the sole right to work the system in France, but also of buying up the inventor's royalty.

At the request of some gentlemen with whom he was in negotiation for the supply of materials for a line 60 miles in Ceylon, Mr. Hodgson has erected five miles of the proposed plant on Brighton Downs, to show, on an extensive scale, the advantages and capabilities of his system as applied to the carriage of produce and materials of all kinds over difficult country.

The wire-rope transport system may be described as consisting of an endless wire rope running over a series of pulleys carried by substantial posts, which are ordinarily about 200 ft. apart. This rope passes at one end of the line round a drum driven by either steam, water, or even horse power, in small farming operations, at a speed from 4 to 8 miles per hour. The boxes in which the load is carried are hung on the rope at the loading end by a wooden Λ-shaped saddle, about 14 in. long, lined with leather, and having 4 small wheels, with a curved pendant, which maintains the box in perfect equilibrium while travelling, and most ingeniously, but simply, enables it to pass the supporting posts and pulleys. By a sliding-ring arrangement the boxes or buckets are easily emptied by tilting without unshipping the saddle from the rope. The boxes can be made to carry from 1 cwt. to 10 cwt., and the proportions of the line and the loading and discharging arrangements can be varied to suit any particular requirement ranging from 10 tons to 1,000 tons per diem. At each end of the line are rails placed to catch the small wheels attached to the saddles of the boxes, by which means the weight, having acquired momentum, is lifted from the rope, and, thus suspended from a fixed rail or platform, can be run to any point for loading or emptying, and again run on to the rope for transport, the succession being continuous and the rope never requiring to be stopped for loading and unloading.

Curves of sharp radius are easily passed, as well as steep inclines, and its applicability to cross rivers, streams, and mountainous or hilly districts, will be apparent at a glance, as the cost of construction increases but little under such circumstances, whilst that of a road or railroad is, perhaps, increased tenfold, and the daily working cost doubled or trebled. The rope being continuous, no power is lost on undulating ground, as the descending loads help those ascending.

In the case of lines for heavy traffic, where a series of loads, necessarily not less than 5 cwt. to 10 cwt. each, must be carried, a pair of stationary supporting ropes, with an endless running rope for the motive power, will be employed: but the method of supporting, and the peculiar advantage of crossing almost any nature of country with a goods line without much more engineering work or space than is necessary for fixing an electric telegraph, without bridges, without embankments, and without masonry, exists equally in both branches of the system.

In the minor applications, such as short transport from mines to railways, the landing or shipping of goods in harbors and roadsteads, and the carriage of agricultural produce on farms, some peculiar features of the system render it specially advantageous. Amongst these are the facility with which power can be transmitted by the rope and taken off at any required point for mining or other purposes. In lines terminating on the seaboard, or on great rivers, a manifest advantage is secured in the facility for taking goods direct to or from ships in harbor or roadstead without transhipment into lighters.

Seen from a distance, the posts which carry the tramway wires at Brighton might be mistaken for telegraph poles, but a nearer inspection reveals a second line of wires on the same level, and upon these two wire-rope lines, supported on standards at intervals varying from 300 ft. to 1,000 ft. apart—according to the requirements of the ground—are suspended iron boxes for the carriage of the goods, which boxes pass on noiselessly and steadily, carried forward by the rope at the uniform rate of five miles an hour—the time required for performing the entire circuit of the line.

In laying out these five miles at Brighton the opportunity has been taken of exemplifying the working of the system under every variety of difficulty that could possibly present itself; thus we have at one part an incline of 1 in 6, up and down, which the rope and boxes work with perfect facility, the descending weights assisting those which are ascending; then there are, besides several bends less acute, two instances of absolutely right angles which are passed with the greatest ease; in some instances the standards are carried to the height of 70 ft. to meet inequalities of the ground, undulating and hilly country being more trying to this system than craggy and mountainous,—such as that for which this plant is designed, and where, from the long reaches taken, fewer posts will be required.

The line is rather over 5 miles long; there are 112 posts, or standards, in the whole length; these standards can either be made of light angle and band iron neatly put together, as in the present case, or of wood. The rope is made of charcoal iron, is 2 in. in circumference, each strand as well as the centre of the rope having a hempen core, to secure ductility. The power employed to drive the rope is a portable 16-horse power engine.

Some of the spans are 600 ft. and 900 ft. in length, and ingenuity has been shown in devising every possible mode of testing the merits of this system of transport; and we are bound to record that all difficulties have been overcome with complete success. The line is capable of delivering 240 tons per day of ten hours, *i.e.*, 120 tons in each direction.

It is intended to divide the proposed Ceylon line of 60 miles into 5-mile sections such as this,—one engine working every two sections, and the boxes passing each section by shunting arrangements, similar to those used at the termini, from one section to another. It is hardly likely that so efficient and economical a means of transport will be for long exclusively confined, as at present, to the conveyance of goods. For ourselves, we venture to confidently predict an early adaptation of the principle of this ingenious system to passenger traffic.

THE BULGING OF WALLS—CAUSE AND PREVENTION.

From "The Building News."

The ugly protruding curvature commonly called a bulge, to which external and front walls seem especially subject, may frequently be traced to original defects of construction. Bulges very often occur at about the level of a floor, and where there is a floor the brickwork of outer walls is commonly weakest. To avoid running the floor-timbers into party walls, they are generally made to rest on the front and back, and the party-wall will often appear in better condition than the front. Immediately below the level of the intended floor, a timber scantling about 4½ in. by 3 in. is laid along the wall flush with its inner face, to receive the ends of the joists. The joists, let it be assumed, are about 10 in. deep, notched to 9 in. at the ends, so as to rise the height of three courses of brickwork. Here, then, bond-timber and joists together make a height of 12 in., or four courses of brickwork. The joists will have a bearing of 6 in. on the wall, and the wall may be supposed to be a brick and a half thick. Now wherever the joists occur, there is a complete interruption of the bond on the inner side of the work, while externally it appears unbroken, the outer face, in fact, being carried up half a brick in thickness, and looking as though the whole wall were perfectly solid and uniform; but the

backing between the timbers too often consists of bats and small pieces put together in a mysterious though incongruous way. So long as the timber remains sound and of its full dimensions, all is well, but this is seldom very long. The manner of converting balk timber into scantlings precludes the permanent retention of its original form. When felled and squared in its native forests, it is thrown into the first lake or river, formed into rafts, and navigated to some port of shipment, where it is formed into cargoes for conveyance across the ocean. The sea voyage over, it may be assumed to the port of London, the timber is again immersed in the water, which usually constitutes its only place of storage till wanted for actual application to some building. As to deals, an architect may specify dryness as a necessary quality, but he must not expect it in timber. He may say that it shall be sound and well seasoned, but water seasoning is all that takes place previous to conversion; and this fact is noteworthy, because as the subsequent shrinkage may be estimated at three-quarters of an inch in the foot, it becomes obvious that so far as the bond timber and joists are to be regarded as forming the inner material of the wall, a subsidence equal to the shrinkage must take place. But the wall does not depend on the woodwork alone, and the irregular filling up between the joists will receive the weight, and so the evil will be deferred. For the time there may be no other visible result than the dropping of the floor from the skirting, and when the latter is of wood, the simultaneous rising of the skirting from the floor. It is when the wooden bond, having shrunk to the minimum dimension of perfect dryness, enters upon its course of decay, that the worst consequences of inserting timber constructionally in walls are developed. The inner face then sinks, and the statical conditions are disturbed, and bulging is inevitable. It was a custom of bygone days to insert timber very freely in walls. Foundations were fortified, as it was thought, by the introduction of a "chain-bond" of large scantling, and many a goodly edifice has suffered from the practice. Great, therefore, have been the improvements adopted in the modern construction of walls. A solid basis is obtained by the use of concrete; wrought-iron hooping has advantageously displaced wooden bond, and the joists are kept as much as possible out of the walls, their ends being supported by brick or iron corbels. Thus all rapidly perishable matters are excluded, and a lasting character imparted to work so executed. Skirtings also are made of stucco instead of wood, and shrinkage in that quarter got rid of. Thus experience and science are gradually removing one of the old defects and disfigurements of buildings—the bulging of walls.

WONDERFUL FLY-WHEELS.

From "Engineering."

A contemporary of ours, in the course of an article intended to treat of economical steam-engines, has proposed, as the great panacea for all irregularities in the movement of mill engines, the use of enormously heavy fly-wheels; the application of a 60 ton fly-wheel, 28 ft. in diameter, to an engine with a 32 in. cylinder and 5 ft. stroke, run at 40 revolutions per minute, being spoken of in glowings terms as the acme of perfection. The writer, in fact, comes "to the conclusion that for pressures of about 100 lbs., and a tenfold expansion, it is better to employ a heavy fly-wheel than a second cylinder to insure regularity of motion;" and he further states that such a fly-wheel "costs, say, to begin with, £6 10s. per ton, if of large size, and when once up it never costs another sixpence." Now, we have no intention to enter, here, into a controversy with our contemporary as to the comparative merits of single-cylinder and compound engines; but we should like to direct the attention of the writer of the statements we have quoted to a simple little calculation which he may possibly find instructive. In the first place, we may remind our contemporary that there is such a thing as friction, and that, within certain limits, the power required to overcome the friction of any bearing varies directly as the insistant weight on that bearing. In the case of ordinary bear-

ings, such as those of a fly-wheel shaft, an allowance of 1-15th of the insistent weight for frictional resistance is a moderate one, and with the 60 ton wheel which our contemporary advocates, the frictional resistance of the crank shaft bearings would be quite 4 tons. Again, these bearings would have to be quite 15 in. or 16 in. in diameter, or, say, 4 ft. in circumference; and when the engine was making 40 revolutions per minute, their surface speed would thus be 160 ft. per minute. From these data we see that the power required to simply keep such a fly-wheel in motion at the speed named would be:

$$\frac{4 \times 2240 \times 160}{33{,}000} = 43.4 \text{ horse power!}$$

But an engine with 32 in. cylinder, 5 ft. stroke, run at 40 revolutions per minute, and worked with steam at from 90 to 100 lbs. pressure expanded tenfold, would only indicate about 200-horse power, and we thus see that if the proportions which our contemporary advocates were adopted, about 22 per cent. of the whole power of the engine would be absorbed in driving the fly-wheel alone! How our contemporary can reconcile this fact with his statement, that the wheel, when once applied, would "never cost another sixpence," we are at a loss to imagine, and we are equally at a loss to know what advantage such a mode of procuring regularity of motion possesses over the practice of "compounding." We can assure the author of the article in our contemporary, also, that if he consults any one practically acquainted with the subject, he will be informed that the cost of replacing an ordinary 20 ton fly-wheel by one of 60 tons—with a view of being able to work 100 lbs. steam expanded tenfold in a single cylinder, without introducing objectionable irregularity of motion—would be far more than that of compounding the engine according to well-known plans. The particular engine with a 60 ton fly-wheel, cited by our contemporary as an admirable example of its peculiar views, was employed in working a rolling mill, and it is possible that, under the circumstances, the heavy fly-wheel may have answered tolerably well. But, even for driving rolling-mills, engines with heavy fly-wheels are getting out of date, the system of direct-acting quick-running engines, without any fly-wheel whatever, such as have been introduced by Mr. Ramsbottom, being found preferable in every way by all who have tried them. Our contemporary's ideas are evidently a few years in arrear.

IRON AND STEEL NOTES.

ON ROLLING RAILS.—At a recent meeting of the Iron and Steel Institute (English), the discussion of Mr. Menelaus' paper "On Improved Machinery for Rolling Rails" elicited a vast amount of information. It seems that the object sought to be achieved in rail-rolling is to avoid stopping the rolls after each passage of the rail under treatment. It is not difficult to comprehend that with machinery running at only 40 revolutions per minute the loss of time and power resulting from reversal every time that 15 ft. of iron has been passed through is considerable; and, if nothing else were learned at the meeting of the Iron and Steel Institute, all must have been convinced that the opinion which had still been entertained by some, that there was no loss of economy from reversing, was erroneous. Perhaps the most remarkable statement made in this connection was that of Mr. C. W. Siemens, F. R. S., who actually suggested that an advantage was obtained by stopping the engine as well as the rolls. For very heavy work, such a system may, indeed, be admissible under some exceptional circumstances, but, as it was objected, if it be unadvisable to stop the rolls, how much more so it must be to stop the whole of the machinery, even apart from the fact that by adopting Mr. Siemens's suggestion it is practically impossible to work two sets of rolls from one engine, which is frequently done at present. The loss of the accumulated power at each reversal becomes of itself an important item in connection with the cost of rail-rolling, and hence the efforts of practical rail-makers to keep their rolls continually going in one direction.

Assuming, then, that the desirability of avoiding the reversal of the rolls is admitted, the question naturally arises, how can that object be most easily and economically accomplished? The pile of iron, it must be remembered, is in a heated state, and has to be passed a certain number of times through the rolls whilst still soft enough to take the impression of them. The use of hot rolls to prevent the abstraction of heat will scarcely be suggested, seeing that it is not required to effect the union of the rolls and the rails, although some of the suggestions appear but little more worthy of adoption. In devising a plan of operation there are necessarily many circumstances to be considered; yet, if simplicity can be combined with efficiency, the result should be a machine that would be generally adopted. The system of roll before roll has been suggested, and where large quantities of metal have to be rolled without change of section, may possess some advantage, but it seems to necessitate an enormously large plant for the performance of a given quantity of work; it has another objection, to which reference will be made presently. The mode proposed by Mr. Menelaus for overcoming the difficulty consists in placing two pairs of

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rolls, one a little behind and higher than the other. In using this arrangement the rail is pas-ed backward and forward, but the rails are never stopped. The rail is passed through the bottom pair, then lifted and returned through the other. It will be seen that Mr. Menelaus has the advantage of two distinct pairs of rolls, very conveniently placed with regard to each other. The lifting of the end of the rail is, no doubt, an inconvenience, but it is a very small one—so small, indeed, as scarcely to be worthy of consideration. In another arrangement proposed by Mr. Brown, this lifting is avoided, but it seems that the remedy is almost worse than the disease. He has two pairs of rolls, one behind the other at the same level, each pair having blanks and working grooves alternately, the blanks in one pair being opposite the working grooves of the other. The rail to be rolled is passed through a pair of blanks in the first pair and rolled in working grooves in the back pair, and is then returned through blanks in the back pair and rolled in the front pair. The rail, instead of being lifted after each pas-age, is moved horizontally, and some of the practical men present seemed to consider the removal of the hot rail horizontally more objectionable, because more liable to twist it out of shape, than the lifting of it.

But that which promises to militate most against the introduction of Mr. Brown's arrangement is its extreme costliness. The stock of rolls has to be doubled for a given number of working grooves, and one-half of the roll surfaces become mere rollers, which do no useful work whatever. And as to changing two pairs of rolls instead of one each time a fresh section has to be rolled, there is is the same objection in the roll before roll system, in that of Mr. Menelaus, and in Mr. Brown's; hence the question raised by some—what is the advantage of reversing? Yet it was admitted the advantages of avoiding the reversal of the rolls far exceeded any supposed disadvantage, and that it was merely a question as to the best means of doing it. Roll before roll, the Dowlais rolls, and Mr. Brown's rolls all having objectional features, and the reversal of the rolls (no matter what means of reversing may be adopted) being more objectionable than either, the Ramsbottom rolls naturally claim attention. Mr. Ramsbottom has all the advantages claimed for the Dowlais rolls, and uses only a pair and a half instead of two pairs of rolls, and thus secures apparently the utmost attainable economy. The three rolls used by Mr. Ramsbottom run in one pair of standards, and being all geared together, the middle roll runs in the opposite direction to those above and below it; the rail can, consequently, be passed through between the bottom and middle rolls, and returned between the middle and top rolls, the whole of the machinery running in the same direction all the time. As in the other system of to and fro rolling without reversing the rolls, the end of the rail has to be lifted after each rolling, but in practice this really seems to be a very small inconvenience, so that, upon the whole, Mr. Menelaus' observation, that if he had another mill to put up at Dowlais, he did not know that he would not adopt Mr. Ramsbottom's plan even, instead of his own, is one which is worthy of the utmost consideration of all who are practically engaged in the rolling of rails.—*The Mining Journal.*

STATISTICS of IRON.—We owe the following datas on the production and consumption of iron in the various countries, to Dr. Beck. The numbers express hundred-weights, and have been collected for the year 1869:

	Production.		Consumption.
	Per entire population.	Per individual.	Per individual.
Great Britain	90,000,000	300	100
France	24,000,000	60	63
United States	20,000,000	75	100
Zollverein	14,550,000	36	38
Belgium	7,250,000	100	65
Austria	6,750,000	18	19
Russia	6,000,000	5	8
Sweden and Norway	5,000,000	100	12
Australia	2,000,000	—	—
Spain	1,200,000	6	10
Italy	750,000	4	8
Total	177,500,000		

MR. CHARLES M. PALMER, at a meeting of the Iron and Steel Institute in May, read a paper "On Iron as a Material for Shipbuilding, and its Influence on the Commerce and Armament of Nations." Fairbairn in a work on iron shipbuilding had pointed out the superior advantages which wrought-iron possessed over all other materials for shipbuilding. The iron plates of a vessel could be so riveted together that the joints would sustain a breaking strain equal, in double riveted joints, to 70 per cent., and in single riveted joints to 56 per cent. of the breaking strain of the solid plate, and this after taking into account part of the plate punched or drilled out in making the joints. It was also set forth as the result of, and deduction from, experiments that if the skin of a vessel could be made of wood 6 in. thick, without joints, that it would be equal to iron plating riveted together of 1¼ in. in thickness. This proportion was established on a comparison of the tensile strengths of the two materials, but so far superior were the facilities for the uniting of different pieces of iron to those of combining wood, that the 1¼ plating would be 134 times stronger than the wood sheathing combined in the ordinary manner used in wood shipbuilding. It was so difficult to fasten the wooden skin of a vessel that the combination was only 1-134th part of the tensile strength of the material. Iron ships weighed 35 per cent. less than the timber vessel, while the displacement of water was the same—greater strength was attainable, higher sailing qualities secured, and less strain liable in iron-built ships. The number of voyages made by iron screw colliers to and from London had risen from 17 in 1852 to 2,440 in 1869, while the tonnage carried in the same period had risen from 9,483 to 1,716,563. Taking the tonnage of British vessels built, he found that of timber there were in 1850 vessels carrying 120,895 tons, and 12,800 tons in iron vessels, while in 1868 the proportion was reversed. In that year the tonnage of timber-built vessels was 161,742, and iron-built vessels reached 208,-101. The same marvellous increase of iron vessels over wooden was also seen in the amount of

steamers constructed. In 1850 the gross tonnage of wood steam vessels was 217 829, while that of iron was only 57,361 ; but in 1868 the tonnage of wood vessels was only 122,282, while that of iron vessels had risen to 1,341,106. America had not advanced iron shipbuilding, because labor was dear, and the manufacture of iron was a costly process. France had made no perceptible progress in adapting her mercantile marine to modern requirements. In England they had, amongst the vessels comprising the British navy, vessels of 130,150 tonnage, and 9,400 of a composite character. Shipbuilding in Holland was altogether on the decline. The Norway shipbuilding was entirely confined to timber vessels ; while respecting Italy, commerce was mostly carried on by English steamers. He was of opinion that the position already attained by England would enable her to keep a foremost place in commerce for some time to come. He would not, in conclusion, dilate upon the beneficial effects of the development of iron steam navigation upon civilization and the peace of nations. We have in a great measure substituted iron for wood, we must now change iron for steel, and he suggested the desirability of devising methods of cheapening and rendering practicable the use of steel in ship construction.

THE IRON TRADE IN FRANCE.—Business is not so dull in France as it was a short time ago, but it can scarcely be said to be brisk : the orders from Paris are few and unimportant, but the state of affairs is better in the south. Rolled iron is in little request in the Haute Marne, but thin sheet, machine iron, certain kinds of special iron, axles rough and turned, wire, nails, and chains are in moderate demand. The long drought has had its effect, and several works dependent on water power have come to a partial or total stand. In the Moselle the metal trades continue in good condition ; work plentiful and prices firm. It is said that the ironworks of Pont a Mousson have engaged to deliver the cast-iron columns of six new furnaces which are about to be set up in France and Luxembourg by MM. Metz, De Dommeldauge and the concessionnaires of the Tongur and Ersch Railway. The Meuse has benefited by the strike of the iron founders in Paris ; the employers at the capital seem determined to withstand the demands made upon them, and are sending their models to be cast in the foundries of the Meuse, as well as in Belgium. The firm of Hayange, which has undertaken to supply the rails, plates, etc., for the Sedan and Séonville Railway, has contracted to do so, it is said, at 230f. the ton. A new house at Lille has just undertaken to furnish the Chemin de fer du Midi with turn-tables, at rates varying between 140f. and 231f. In Belgium merchant iron remains without animation, but sheet iron is in good demand, and the rates continue firm ; rails remain at the high price of 180f., which they have never before reached for ten years. The following are the average prices during the last ten years for rails of best quality, all accessory pieces supplied with them :

	Per Ton. Fr. cents.	Per Ton. £ s. d.
1860	159 75=6	7 9
1861	161 50=6	9 2
1862	150 45=6	0 0
1863	149 20=5	19 0
1864	160 75=6	8 7
1865	161 80=6	9 5
1866	160 10=6	8 10
1867	156 70=6	5 4
1868	148 80=5	19 6
1869	158 25=6	6 7
Present price	180 00=7	4 0

The rate of exchange makes the English equivalents in the above table slightly too high—about 2d. in the pound sterling.—*The Engineer.*

RAILWAY NOTES.

RUSSIAN PROGRESS.—The great feature at present in the material progress of Europe, is the activity which Russia is displaying in the work of railway development. The Czar's Government has laid aside for the nonce—although it may still perchance cherish them—its historic schemes of political aggrandizement, and has applied itself to the sounder and more pacific task of utilizing more fully the territories which it already possesses—territories which are surely vast enough, in all conscience. With this object, an extensive network of railways is being rapidly carried out, and Moscow has already become a terminus of six great lines. The effect of this extensive construction of Russian railways has been to give a stimulus to the production of rails in Great Britain, and all over the continent—in fact, the Russian demand for rails, and the revival of railway enterprise in the United States, are unquestionably the principal causes of the amelioration which has been witnessed in the British and European iron trade during the last two years. We have on more than one occasion directed attention to the aspect of affairs; and in support of our present argument, we would cite the exports of rails and railway iron made by Great Britain and Belgium to Russia during 1869, 1868, and 1867:

	1867. Tons.	1868. Tons.	1869. Tons.
Great Britain	124,693	101,290	252,827
Belgium	67,095	45,430	67,419
Total	191,788	146,720	320,246

If figures ever proved anything, they are conclusive, we should imagine, as to the powerful influence for good which the prosecution of Russian railways exercised last year upon the European rail trade. The figures are also interesting from another point of view, since they show that—for the present at any rate—Belgian competition is a bugbear. The fact is, Belgian means of production are so limited, as compared with those of England, that, even when Belgian competition has done its worst, it is scarcely felt in prosperous years. In 1869, Belgian production was taxed to the utmost, but we sent more rails than ever into Russia ; and although the aggregate exports of rails from Belgium to all countries increased last year to 136,063 tons, as compared with 70,550 tons in 1868, the aggregate exports of British railway iron also increased from 583,488 tons, in 1868, to 895,848 in 1869, showing a progress last year of 312,360 tons, or more than double the whole of the Belgian export. When croakers, who affect to believe in the decadence of British commerce,

begin to indulge in idle assertions and baseless vaticinations, they would do well to "read up" a few such facts as we have just cited.

It is not only in the matter of rails that Russia has made her influence felt of late as a great consuming State, but she has also had to purchase a large amount of rolling stock, engines, trucks, and plant. In all, contracts have been let for 1,200 locomotives for Russian lines during the last three years; and at £2,500 per engine, the money value of these contracts, cannot be taken at less than £3,000,000. Of the 1,200 locomotives, about 370 were ordered from English and Scotch firms, so that Great Britain obtained a solid slice of the £3,000,000—about £900,000. Orders of some importance for carriages and trucks, on Russian account, have also been received by several leading British firms and companies. It must be confessed, however, that we have not thus far been so successful in obtaining orders for rolling stock from Russia as in securing contracts for rails, a very large proportion of the locomotive orders given out having been secured by Prussian and French houses. Even Belgium has been set aside in the matter of Russian locomotives by French adroitness. Thus, when contracts for 30 locomotives for Russia were recently proposed to some Belgian works at £2,520 per engine, they stood out for £2,640 per engine, while the administration of the great French establishment at Creusot came forward and undertook the whole work at £2,472 per engine. Probably financial consideration firms were so terribly bitten with the almost valueless obligations of disappointing Spanish railways that they have probably not been very eager to accept Russian securities in payment for work and labor done. But French intelligence has appreciated the fact that there is a wide difference between obligations bearing the tangible and substantial guarantee of the Russian Treasury and the bonds of struggling Spanish companies. This difference is certainly very material, for Russian financial honor has never been impeached, and as the whole resources of Russia are pledged for the payment of the interest upon Russian railway bonds—at any rate upon such of them as bear the seal of the Russian Treasury—they are virtually State funds; at any rate, they bear the same proportion to Russian funds as Indian guaranteed railway debentures bear to Indian funds. It is credit which has carried French, English, and German locomotives into the heart of Russia; it is credit which has caused the great Russian railway network to spring into existence; it is credit which is securing to Russia all the material blessings of an advanced civilization.—*Colliery Guardian.*

Railways in Japan.—The city editor of the "Times" speaks as follows of the Japanese loan now being negotiated in this country: The London Stock Exchange, as the centre of the financial negotiations of the world, is about to open a new connection. A loan of £1,000,000 for the Imperial Government of Japan, contracted under the authority of Mr. Lay, as special commissioner, is introduced by Messrs. J. Henry Schröder & Co. The price is to be 98, and the rate of interest 9 per cent. per annum; the principal redeemable at par within thirteen years by annual drawings. The object is to connect by railway Yeddo, the capital of the empire, with Yokohama, Osaka, and the port of Tsuruga—points which comprise several millions of inhabitants and the most active trading communities of the country. As a special security the entire Customs duties of the Empire, said to amount to £600,000 or £700,000 per annum, are to be assigned, together with the proceeds of the intended lines, which are all to be completed within three or five years; and the Oriental Bank Corporation, who have had long experience of pecuniary intercourse with the Japanese Government and people, are to be the agents for the receipt and transmission of these funds. Although to external nations Japan is as yet a comparatively strange country, its capacities have been illustrated by the enormous development of its trade both with England and the United States during the past few years, and the conclusions of the various merchants engaged in this new and attractive branch of commerce seem favorable alike to the commercial sagacity and good faith of the Government and people. It may reasonably be anticipated that this sagacity and good faith will not break down in the commencement of their public monetary relations with the West, especially when those relations are established to supply means for augmenting their wealth, but will be so maintained as not only to justify any boldness our merchants may now be disposed to display by becoming investors, but to lead to a long financial intercourse, in which we may constantly increase our operations, and at the same time with safety gradually reduce the terms upon which they are undertaken.

ORDNANCE AND NAVAL NOTES.

Ships' Decks and Vertical Fire.—The trials which took place lately at Shoeburyness against a target plated and constructed to represent a ship's deck, proved very conclusively how defenceless even a stout modern iron-clad would be against a well-directed vertical fire, if such a fire could be delivered. The target consisted of six iron deck beams, 10 in. deep, protected by 1 in. iron plating (in two ½ in. plates) and an upper stratum of 5 in. deal planking. Over half the target the plating was 1¼ in. thick (in two ¾ in. plates), the wood upon this portion being reduced to 4½ in. To avoid the delay and expense which would have resulted from vertical practice against a target placed horizontally, unless that target had been made of an extravagant size, the deck was placed upright, and the pieces were fired with charges calculated to give a striking velocity equal to that which the projectiles would have if fired vertically at considerable ranges and elevations. The attack was represented by the 13 in. sea service mortar and the 9 in. rifled howitzer, both placed at twenty yards from the target, and in a position which obliged the projectile to strike at a considerable angle of incidence. The 13 in. spherical shell weighed, filled, about 200 lbs.; the 9 in. shell about 240 lbs. The charges were: 13 in., 7 lbs.; 9 in. howitzer, 3½ lbs. Only four rounds were fired, two against each portion of the target, one of these two being with each piece. Both the 13 in. went through the target, and one of the rounds with the 9 in. accomplished a like effect. After this not much argument is needed—if, indeed, it were needed before—to prove the terrible havoc which vertical or high-angle fire would be capable of producing upon ships of war; and the importance of vigorously prosecuting experiments

with a view to the introduction for coast defence of some pieces capable of delivering such a fire with tolerable accuracy. Hitherto the inaccuracy of high-angle fire has been the great obstacle to its success. This, coupled with a sort of impression that projectiles animated only with the velocity due to their falling weight would be easily stopped, has caused this subject to hang fire. Nevertheless, many competent judges have long urged the importance of the question; and for some years the introduction of an efficient piece for high-angle firing has occupied, off and on, the attention of the Ordnance authorities. It is time that those deliberations and experiments should bear fruit; and the results will, we hope, give the impetus to the inquiry which it has long needed. If we cannot get through the sides of modern ships, we can at least attack their bottoms by torpedoes, and introduce shells through their decks. What a very disagreeable place a ship will be to fight in ere long!—*Pall Mall Gazette.*

EXPERIMENTS WITH THE MONCRIEFF GUN-CARRIAGE.—Yesterday, at 12 o'clock, A. M., the new gun-carriage, made in the Royal Gun-Carriage Factory of the Royal Arsenal, under the supervision of Colonel Clerk, R. A., the superintendent, from designs of Captain Moncrieff, for a 12-ton gun, was placed in position at the proof butts on the Plumstead Marshes, and practically tested in the presence of the Select Ordnance Committee and a large number of distinguished military officers and other gentlemen.

The barbette gun-carriage, which was mounted with one of Armstrong's 12-ton rifled muzzle-loading guns, is the first of the same size, and somewhat on an improved principle to the last made for a 7-ton gun, the lifting and breaking gear being more complete, and Captain Moncrieff has also added an apparatus for lifting the shot to the muzzle of the gun, which is a decided improvement. The following are the weights of the different parts:—Carriage, tons. 2-5¼; platform, tons, 9-1: and elevator, tons, 14¼; balance, tons, 15-1¾; total gear, 67 tons. Before the experiments commenced, Captain Moncrieff explained to the visitors and the committee the various parts of the carriage, and pointed out the new rear axletree to the elevator, which had been made since the trial in private last week. About 12.15 the gun was loaded with a charge of 30 lbs. and a shot of 240 lbs. and gently raised into position and fired, when the recoil was very satisfactory, bringing the great gun down into rest with the greatest ease. The next charge was increased to 40 lbs. powder. In ramming up this time, the pull of the rack on the right side was allowed, by the man attending to it, to fall in gear, and so prevented the gun rising properly, and it had to be worked back to free the pull again. On examining the pull-pin it was found to be bent, which necessitated the removal of the right pull altogether; and after the firing of this charge the gun recoiled with admirable ease to the full; but, as the supports had slightly shifted, these temporary adjuncts were strengthened, and then the gun was again raised and fired with a charge of 43 lbs. when, strangely enough, the recoil thrust the whole platform forward about half an inch instead of rearward. The whole of the experiments, however, were pronounced to be highly satisfactory, and Captain Moncrieff received the congratulations of the officials present, when he explained that the experiments had been made at great disadvantage. The gun, in getting into firing position, rises on the elevator to the height of 13 ft. 3 in., and the area required for the platform to work freely is 19 ft. by 11 ft., and the shot used at each service is a 250 lbs. round iron cylinder. At the conclusion of the tests a minute inspection of all the gear and the carriage was made, and as everything was found to be in complete working order, Sir Hope Grant and Sir David Wood, with the members of the Ordnance Select Committee, congratulated the inventor on the success of the experiments. Captain Moncrieff said he intended to simplify the carriage supports considerably.—*Army and Navy Gazette.*

THE alteration of the Prussian needle-gun has been sanctioned by the King, in consequence of which the two or three millions of rifles in the possession of this Government will be remodelled. The improvements introduced aim at simplifying the loading, and increasing the force and range of the ball. For this purpose the caoutchouc ring of the Chassepot has been adopted, which, helping to close the breach by spontaneous action, renders it unnecessary to press the valve down so tightly. In addition to this, the weight of the ball has been reduced from 31 to 21 grammes, which, with the charge remaining at 4.9 grammes as formerly, considerably augments the propelling force. To fit the reduced ball for the old barrel the *zund-speigel* has been proportionately enlarged, a proceeding, the practicability of which was proved by a similar alteration adopted some time ago, and further attested by a year's experiments with the weapon in its present, latest form. On the needle-gun being first taken into favor in 1841 it had a ball of 15.43 millimetres, but the heaviness and consequent want of speed observable in the missile causd it to be soon reduced to 13.6 millimetres, which size has now been further diminished to 12 millimetres. The total weight of the new cartridge is 32 grammes, instead of 40 grammes, as heretofore, so that the soldier will henceforth carry 95 instead of 75 cartridges, without experiencing an additional burden. Besides this, the needle is now made to move in a narrow hole, into which it fits exactly, instead of the wider one of the old gun, and a piece of oiled paper is placed at the bottom of the cartridge to clean the needle after each discharge, and serve some other purposes of minor importance. By these improvements it is hoped to raise the Prussian needle-gun, which has the glory of being the first breech-loading rifle ever introduced into an army, to the latest requirements, and make it practically a match for all its manifold rivals. Though among these latter there are some with a ball of only 11 and even 10 millimetres, it is contended that the advantage derived from this small calibre is of no practical use in the field, and that the Prussian rifle, in its present form, fires quite as rapidly and as far as the purposes of warfare require. That the alterations resolved upon are not very costly is owing to the ingenious construction of the *zund-spiegel*, which admits of a small ball being shot out of a comparatively wide barrel.

MR. CHILDERS ON WHITWORTH GUNS.—Mr. Childers' argument for undertaking expensive experiments with Whitworth guns is worthy of notice. It runs as follows: The navy are thoroughly satisfied with the service 12-ton guns; they consider also that the trials of the service 25-ton gun "have been entirely satisfactory." But they require more

powerful guns for ships of the Devastation and Thunderer class. Therefore they propose—what? Not, as would naturally follow from the foregoing reasoning, to make these new and more powerful guns of the construction which, up to 25 tons—that is to say, as far as it has been tried—has been "entirely satisfactory," but to run off the line and to try quite a different weapon. Sir Joseph Whitworth himself is very fond of appealling to the results of experiments made with some tiny model gun, as a 1-pounder or a 3-pounder, as evidence of the infallible success of his shot, or his metal, or his system, when applied on a larger scale. Mr. Childers reverses that process. From the admitted success of a 25-ton and other service guns, he argues the necessity for the introduction of a totally different system of ordnance. Of course this process of reasoning will lead you exactly where you please. If the success of a system be an argument for altering it, the failure of a system may naturally be accepted as an argument for introducing it. Hence the Whitworth gun which, as we have before shown, was reported unsuited for her Majesty's navy when tried in 1867 as a 7-ton gun, is now to be tried on the 35-ton scale.—*Pall Mall Gazette.*

A new method of testing thick armor for her Majesty's ships has been introduced during the past week at Portsmouth in the trial of two immense plates for the Glatton and the Devastation breastwork monitors. Hitherto the practice has been to fire at the plate with spherical shot from the smooth-bore 8-inch gun, but the method now brought into use by the Admiralty substitutes the 7-inch muzzle-loading rifled gun with chilled shot for the smooth-bore. The powder charge varies according to the thickness of the plate under test in the following degrees: For 12-inch plates 21 lbs.; for 11-in. plates, 18½ lbs.; for 10-in. plates, 16½ lbs.; for 9-in. plates, 14 lbs. The distance between the gun and the plate is 30 ft., and four shots are fired at the plate within an area of two sq. ft. The plate for the Glatton was from the rolling mills of Messrs. Charles Cammel & Co., Cyclops Iron and Steel Works, Sheffield, measuring 10 ft. in length, 3 ft. 6 in. in breadth, 12 in. in thickness, and weighed 7 tons 2 cwt. The plate for the Devastation was from the rolling mills of Messrs. John Brown & Co., Atlas Iron and Steel Works, Sheffield. Its dimensions were 14 ft. in length by 4 ft. 6 in. in width, and 10 in. in thickness, and weight 10 tons. The average penetration of the shots in the 12-in. plate was 7.2 in., and in the 10-in. plate the penetrations were 6.3, 6.8, 6.8, and 7.8 in. respectively. It is a remarkable feature in the manufacture of these enormous slabs of iron for our new turret-ships that they are bent to the required form direct from the rolls, and when at cherry heat. To bend such plates cold would give them a certain amount of brittleness, and render them liable to "star" when struck by shot.

Accounts from Cherbourg state that the Imperial yacht L'Hirondelle during one of her late trial trips acquired a speed of 14 2-10 knots, and that from the time the fires were lighted, only 20 min. elapsed before the steam was up and the vessel ready to start. L'Hirondelle's power is equal to 1,800 horses.

A new Victorian flag, which, at the suggestion of the Admiralty, has been designed as the distinguishing mark of the Victorian mercantile navy, has been formally adopted by the Government. The ensign will have five white stars on the blue ground, and the "jack" five white stars in the cross of St. George, which forms the central line of the pattern.—*Melbourne Argus.*

The experiments carried on by the special committee during the past week at Shoeburyness, under the presidency of Colonel Elwyn, Royal Artillery, Commandant of the School of Gunnery, assisted by Capt. Arthur, R. N., and Major Millar, V. C., Royal Artillery, to test Sir Joseph Whitworth's 9-in. 14½-ton steel muzzle-loading hexagon bore rifled gun, for range and accuracy, were resumed on Wednesday. The gun up to this date has fired 118 rounds, with 50 lbs. rifle large grain powder charges, and shot and shell of about 115 lbs.

The Portuguese Government are asking for a supply of 10,000 rifles on the Martini-Henry principle, and 1,000,000 cartridges, also for 14,000 butt ends for Enfield rifles and 1,000,000 cartridges for the Snider arm.

The new iron armor-plated double-screw ship Invincible, 14, ran six hours in the Channel, outside Plymouth Harbor, on Saturday, being three hours to the westward and three back, with a very satisfactory result.

ENGINEERING STRUCTURES.

The Darien Ship Canal.—Whatever advantages might result to the commerce of the United States, and of the world, from the opening of an inter-oceanic ship canal across the Isthmus of Darien, the practicability of such a work is dependent upon the discovery of a depression in the Cordilleras by the Government surveying party now on the ground. As yet, the accounts received of the progress of the survey do not promise much for the success of the expedition, except that it has disproved the theories of Gisborne and Cullen and conclusively demonstrated that the narrow pass or valley, which the latter claims to have discovered, extending from ocean to ocean, has no existence save in the imagination of its pretended discoverer. This is certainly discouraging, although the explorations and surveys will be continued in the hope of finding a practicable route through some other section of the Isthmus.

From a somewhat intimate knowledge of the topography of the narrow strip of land uniting the two continents, we incline to the belief that, with the exception of the pass now occupied by the Panama Railroad, there is no depression in the mounta n range through which a canal could be projected. Unless such a depression is discovered, however, the canal project may as well be adandoned, as far as Darien is concerned. The tunnelling scheme, proposed by some impractical genius, which proposes to cut a tunnel "of sufficient capacity to pass the largest-sized man-of-war, with topgallants lowered and yards squared," through from 5 to 7 miles of mountain, will never for a moment engage the serious attention of capitalists. It is doubtful, therefore, if a suitable route will be discovered across the Isthmus; but even if the engineering difficulties are found to be less serious than

at present supposed, others exist touching its practicability when finished. The most important of these is that it would be available for steam vessels only. Sailing vessels would not only have to be towed through the canal, but, before they could be fairly started on their way across the Pacific, it would also be necessary to tow them from 150 to 200 miles out to sea. During the greater part of the year the entire section of coast from the equator to 15 deg. north latitude, is free from winds available for sailing vessels. Geographically it is known as the region of the southeast and southwest monsoons, and extends from about 9 deg. south latitude to the Equatorial Calm Belt, which touches the southwest coast of Tehuantepec at about 15 deg. north latitude; and longitudinally from 78 degs. to 119 degs. west from Greenwich, including within these limits the entire west coast of Central America, Darien, Columbia, and Equador. During most seasons this is a region of prevailing calms or light baffling winds. —*The Iron Age.*

A NEW MOTIVE POWER (?)—Considerable ingenuity has been shown by Mr. Robert Side, of 126 Union street, Borough, in the combination of certain mechanical powers by which he claims to produce a machine which can be worked at a considerably cheaper rate than engines worked by steam, gas, or air. The substance of the invention consists in the use of cranks working in pairs one within the other, or opposite to each other in opposite directions, for imparting a rocking motion to weighted beams having no fixed axes of motion, but so constructed that the crank pins move in slots in the beams. We recently inspected a working model of this invention, as well as the same arrangement on a large scale, with which Mr. Side proposes to produce an engine of 5-horse power. The apparatus consists of two horizontal shafts lying parallel with each other, and connected by toothed wheels, which impart rotary motion to the shafts in opposite directions. The shafts are cranked and are so adjusted that the cranks move one in the other during rotation. The cranks terminate in pins which take into two slots in a balance beam. As the shafts revolve, one of the cranks falls outwards and the other rises inwards ready to be forced down in its turn by the falling end of the beam. A very slight force exerted at one end of the beam causes that end to descend, the gravitating power operating upon the cranked shafts, and thus imparting rotary motion which is to be transmitted by gearing for application to any desired purpose. A fly wheel assists the lever beam past the dead points. The novelty in this invention consists in having two revolving centres instead of one fixed centre. By this means every pound of pressure is thrown on the descending crank or centre, and becomes so much motive power. The inventor calculates that having a beam equal to 1-horse power and adding 1-horse power of steam on the upper end of the beam, he will then be working with 2-horse power, one of iron and one of steam, thus saving 50 per cent. of steam power. But it appears that it is not necessary to have a pressure of steam equal to the weight of the beam, as it only requires a pressure equal to 1-16th part of the weight of the beam to rock it from one centre or crank to the other. Hence Mr. Side states that a saving of 90 per cent. of steam power results. We are by no means so sanguine as to endorse this opinion, but the question is interesting, and we await the completion of the large engine to test the actual results.—*Mechanics' Magazine.*

THE CAUSES OF THE RICHMOND DISASTER.—More recent investigation assigns to other causes than those hitherto alleged, the fall of the room lately occupied by the Court of Appeals in the Capitol building in Richmond. It is now denied that its floor was ever supported by pillars beneath in the room called the Hall of Delegates, either before or after the hall was constructed. The size of the latter is 80x34 ft. Over it were two rooms whose floors rested on four girders dividing five spaces each about 16x34 ft. The girders were spliced timbers 13x20 in. in thickness, the first one from the eastern wall being under the floor just in front of the railing of the Supreme Court bench, and the second midway from that to the partition between the two rooms. In the centre of this second girder a mortise had been let in from above—with reference to some former columns of partitions—of 4x6 in. and 15 deep, reducing the material at this point to about 9½x20 in. The girder itself was of brittle heart-pine, and had otherwise been weakened by mortise and auger-holes. Finally, on this second girder there rested the pillars of a gallery within the room where the disaster took place. The room itself was about 34x50 ft.; deducting the bench inclosed by the railing, a space of about 34 ft. square was closely packed with as many persons as could stand in it, and in the gallery which stretched across it. All that supported the weight in the centre of this space was the girder we have described. When it gave way it carried with it the gallery, and the entire plastering from the ceiling of the room also fell, with its framework. The floor took a funnel shape at the moment of the occurrence. Girder No. 1 remained unbroken; No. 2 broke in the centre; No. 3 cracked, but still remains, supported by a prop since placed beneath it. The entire mass of about 400 people, the gallery, the ceiling and its framework, fell together through the funnel-shaped cavity, a distance of about 25 ft. to the floor of the hall below. It will be recollected that inside alterations that weakened the supports were believed to have much to do with the recent fall of the wing of the Court House in Chicago. In the present case the building itself is not believed to be insecure.—*New York Tribune.*

THE NAVIGABLE DOCK.—The author commenced by stating that the improvement of the navigable dock had for the last ten years occupied the attention of the Institution of Naval Architects. Ordinary floating docks or lifts could only be deemed, when they reached their destinations, as simple *succedanea* for the ordinary dock constructed on *terra firma*, and in positions where the rise and fall of the tide was so small that they could not be made available for the great vessels of which their present navy was composed. The difficulties attending a mere floating dock were very great. The difficulties of transportation and expense, added to the slowness of the process, seemed to demand some more reasonable mode of relief. The desired result could only be obtained by one firm connected structure, totally independent, sound, and complete as any steamship, and capable not only of caring for herself, but perfectly adapted to rescue and safely house at sea, in moderate weather, the

largest iron-clad they now possessed or might intend to construct. His investigations and experiments resulted in the form proposed, and which he called a serviceable self-reliant ship dock, combining within her own accommodation every requisite to be sought for, not simply in foreign dockyards, but equal to any of the home dockyards. The Admiral then, with the assistance of diagrams, described his floating dock, the length of which he stated to be 500 ft., the extreme breadth 110 ft., the displacement at 27 ft., 25,000 tons, weight of the vessel and engines 13,000 tons, horse-power 6,000 tons, speed 10 knots. This would give the means of docking vessels requiring repair, of saving the necessity of a return to England, or to any place distant to seek for relief if disabled; and finally, with an unexampled power of despatch of examining, cleaning, and repairing a whole fleet in succession. As to despatch, the power of the turbine—that of removing 2,000 tons per minute—would in that minute fix the Warrior on her block, thus removing all the labor or anxiety as to her floatation. Seven minutes would raise her keel to the sea level, and twelve minutes would raise her 3 ft. above the wash of the sea.—*Mechanics' Magazine.*

STEAM COLLIERS.—Among the many improvements and enterprises brought before the public during the past year, there is none more important than the introduction of iron steam-colliers on our coast, and for this we are indebted to Mr. Walworth D. Crane, a young New York merchant, who for three years past has labored incessantly to establish the line. In June last the pioneer ship, the Rattlesnake, 500 tons cargo capacity, made her trial trip on the Delaware river. This vessel was followed by the Centipede, Mr. Crane making some improvements in her construction, and in September last he placed four more under contract, viz.: the Achilles and Hercules, 1,000 tons each; the Panther and Leopard, 800 tons each; and these last-named reflect credit upon his sagacity and skill.

The benefits of cheap coal transportation from the great shipping points cannot be too highly estimated; and, as New York and its adjacent ports on the Hudson river are becoming the great depots for coal, it is here our merchants and manufacturers must look for supplies, instead of depending upon Philadelphia, which is the terminus of only one coal-carrying road, while here we have the outlet of the Delaware and Hudson Company, the Delaware, Lackawana, and Western Company, the Pennsylvania Coal Company, the Wilkesbarre Coal and Iron Company, and of the products of numerous individual operators. New York, as the metropolis, and on account of its geographical position, must become the great coal mart of the country.—*N. Y. Tribune.*

NEW BOOKS.

CROOKES AND RÖHRIGG'S METALLURGY. A Practical Treatise on Metallurgy, adapted from the latest German edition of Prof. Kerl's Metallurgy, by Wm. Crookes, F. R. S., etc., and Ernst Röhrig, Ph. D., M. E. 3 vols. London: Longmans, Green & Co. New York: John Wiley & Son, 1868–1870.

Prof. Kerl's "Handbuch der metallurgischen Hüttentunde" (4 vols., 1861-65), of which "Crookes and Röhrig's Metallurgy" is essentially a translation, is almost the only recent work which contains a full and detailed statement of the whole subject. Since Karsten's treatise (1831-32) metallurgical literature has been more or less fragmentary. Scheerer's "Classical Lehrbuch der Metallurgie" (1848–53) did not reach the completion of its second volume. Rivot's "Traité de Métallurgie" (1859–60) likewise remains unfinished; and English readers have been waiting impatiently for many years for Prof. Percy's concluding volume. A translation of Kerl's treatise into English is therefore timely.

The design of the translators was not merely to translate, but to adapt Kerl's work to the wants of English and American metallurgists. Many portions have been condensed and many omitted altogether, while considerable new matter has been added to represent the progress of metallurgy since the completion of the original treatise.

The recent appearance of the third and concluding volume enables us now to judge of the work as a whole.

As a translation, the work is marred by haste and carelessness, and by what looks, in some instances, very much like unfamiliarity with German terms and usages; as may be seen from the following extracts:

In Kerl, iv., 370, we read:

"Die Röstung wird so lange fortgesetzt, bis eine genommene und ein wenig angefeuchtete Probe nach *einigem* Liegen an der Luft keine Reaction *auf* Eisenvitriol mehr gibt."

This is rendered, i., 637:

"The roasting is continued until a slightly moistened sample has no reaction *upon* iron vitriol after *long* exposure in the air."

What the significance of any reaction upon iron vitriol would be in this instance, it would be hard to say.

Kerl, iv., 416, we read under the heading "Scheidung des Goldes vom Kupfer:" "*Mittelst Quicksilbers* lässt sich das Gold nur unvollständig ausziehen."

Crookes & Röhrig render this, i., 674, by the absurd statement:

"Gold cannot be perfectly separated from copper."

Kerl, iv., 379: "Vor der Behandlung des Röstgutes mit unterschwefligsauren Salzen empfielt sich ein Auslaugen desselben mit Wasser, wil Kiss es thut, *nicht*, weil das Goldchlortür in heissem Wasser sich sogleich in Chlorid und metallisches Gold zerlegt, in kaltem Wasser zwar unlöslich ist, aber davon im Dunkeln line zersetzung auch langsam erleidet."

Crookes & Röhrig, i., 646: "It is advisable to wash the roasting mass with water previous to its treatment with hyposulphites. The chloride of gold by the action of hot water, is decomposed into protochloride and metallic gold, and though insoluble in cold water, is slowly decomposed by it in darkness."

The omission of the negative may have been an oversight, but the use of roast*ing* for roast*ed*—a mistake of frequent occurrence throughout the book—and the confusion of the different chlorides of gold, cannot be accounted for on any such charitable hypothesis.

Kerl, ii., 611: "Damit die gaare nicht sofort beim Niederschmelzen des Kupfers eintritt, schlägt man Kupferhaltige Eisensauen zu."

Crookes & Röhrig, ii., 254: "To prevent the refining taking place at the smelting of the copper, cupriferous iron deposits are added."

Kerl, ii., 58, gives the lead production of Carinthia by the "Aerar" and "Privatwerke" separately. The translators seem not to have known that the terms *Aerar* and *aerarisch* (Latin Aerarium) are in general use in the Austrian empire in the sense of *governmental*, or perhaps have presumed that English readers would know what was meant by "the Aerar Smelting Works."

It requires no diligent and patient search to discover inaccuracies of translation such as the above. Any one acquainted with Prof. Kerl's work will notice similar inaccuracies—some important, others slight—on almost every page of the first volume, and although the second volume is generally more accurate, it is not by any means free from very bad blunders.

Appreciating fully the difficulty which the editors experienced in translating technical terms, for which there is no precise equivalent in English, we will not criticise severely the terms they have have chosen, objectionable as many of them are. But the ever recurring confusion of terms is a fair subject for complaint.

We have, for instance, the term *Ofenbruch* applied to the adhering masses broken from the walls of furnaces at the end of a campagne, translated in some places by "soot," in others, "metallic soot," and again by "metallic fume," neither of which strikes us as the best possible. But any one of the three, properly defined and adhered to, might answer. What makes it still more confusing is, that "Rauch" from lead furnaces, applied in the original to something entirely different from Ofenbruch, is translated indifferently by "lead fume;" "lead smoke," "metallic fume," or simply "fume," and again, "Flugstaub" is also translated by "smoke," "metallic smoke," and "metallic fume." The same confusion is noticed in translating the three related terms *Abzug*, *Abstrich* and *Bleidreck*. Saigern is sometimes correctly translated by *liquation* and at other times by *melting*. The confounding of *smelt* and *melt* is common throughout the work. Bleiische Zuschläge we find translated "fluxes," and Vorschläge sometimes "fluxes," and sometimes "dross." Such errors could only have resulted from ignorance of the sense in which these terms are used by German metallurgists.

But it is not only with the technical terms that the translators have made such sad work. A too rigid adherence to the German idiom has often made sentences almost unintelligible. Were we to cite some of the long complicated passages which show an attempt on the part of the translators to make English words conform to the rules of German syntax, we should consume too much space. We will only mention, in passing, the translation of "eigentliche Silbererze" by *real silver ores*, and the following amusing rendering:

Kerl, ii., 593: ". . . wobei ein grosser Theil des Kupfers chlorit . . . . wird."

Crookes & Röhrig, ii., 241: "Thus a great part of the copper *chlorinates*."

The invariable use of the English comparative in translating such words as "grösseres," "längeres," "höheres," etc., which in the original imply no comparison, but merely "rather large," "moderately high," and the like, is not only very perplexing to the reader from the absence of the expected particle *than*, but in most cases conveys an impression not intended in the original.

Should we continue citing the inaccuracies of translation which we have noticed in reading the the work, we could fill a small volume, but the above are fair average specimens of the way in which Kerl's treatise is presented to its English readers.

Although faulty translation is the principal defect of the work, we have also to complain in some instances of a too faithful adherence to the original. The latter contains some evident misprints and misstatements—no work of its size and character can be, in the nature of things, entirely free from them—and these are generally reproduced in the translation; the original contains no table of errata. Besides, there are many processes described by Kerl as in operation at the time his work was written, which have since been superseded by others; yet the English edition gives them without any intimation of their having been abandoned.

This, we think, can only be explained by supposing the translators ignorant of the present state of metallurgic practice in Germany, and that the translation was undertaken without the advice and assistance of Prof. Kerl.

Conspicuous among the parts of Kerl's treatise which are entirely omitted in the translation, are the methods for assaying ores. This omission is justified by the translators "as the new edition of Mitchell's 'Manual of Practical Assaying,' fully treating of this subject, may be considered as adequately representing that branch of metallurgy." As Mr. Crookes is the editor of this new edition, we admit that from his stand-point this reasoning is just, but we venture to think that those practically interested in assaying would find Kerl's treatment of the subject much better than that of Mitchell and Crookes. A serious omission of a different character is, that no mention is made of Mr. Wurtz's name in connection with the sodium-amalgamation process. Mr. Crookes, as is well known, claims to be an independent discoverer of this process, but has already acknowledged in the "Chemical News," of which he is editor, that Wurtz's publications on the subject were prior to his own. In the work before us the editors devote considerable space to what they term "Mr. Crookes' process of extraction by means of sodium-amalgam," giving mainly testimonials of scientific authorities and practical metallurgists to the great value of Mr. Crookes' discovery. Mr. Wurtz not only comes in for no share of the credit, but Prof. Silliman's statements, made before the National Academy, Washington, 1866, concerning the results of his experiments in testing the value of Mr. Wurtz's process, are coolly taken by Mr. Crookes to swell his own praise! This evidence of petty selfishness on his part will not tend to enhance his reputation as a truthful and impartial author. As said before, much new matter has been introduced into the English edition. This has been largely taken from Dr. Ure's Dictionary of Arts, Manufactures and Mines (1860), though considerable matter is derived from other and more recent sources. This is principally seen in the third volume, where the subject of steel has received an extended, and, on the whole, excellent treatment. The Supplement to the last volume, comprising over two hundred pages, is intended "to bring the work to the level of the actual state of the science and practical experience," and is made up of "articles and reports on improved processes from some of the English and foreign journals." In compiling this

Supplement Messrs. Crookes and Röhrig have shown very little industry and discrimination, and have entirely neglected their duties as editors. Some of the articles, such as "Bell, on the Chemistry of the Blast Furnace," are most excellent, and need no pruning, but many of them are merely specifications of patent processes, not in actual operation and often wanting in novelty.

Gruner's detailed description of the desilverization of lead by means of zinc, in his admirable monograph, "Etat actuel de la Métallurgie du Plomb," published in the "Annales des Mines" (1868), is only given in an abridged form taken from a translation in an English technical journal. Not only is the monograph not mentioned, but the valuable details of the process as actually practised, together with drawings of apparatus, are entirely omitted.

The above criticisms have not been written with any hostile feelings towards the work or its editors. The writer being familiar with the original, and considering the names of the translators sufficient guarantee of the correctness of the English edition, heartily recommended it without examination. But he found, after careful perusal, that it was so grossly inaccurate as to be useless for his purpose, and he wishes therefore to put others on their guard against relying too implicitly on the work as a reproduction of the excellent and well-known treatise of Prof. Kerl.

SPON'S TABLES AND MEMORANDA FOR ENGINEERS. —Selected and arranged by J. T. HURST. London: E. & F. N. Spon. For sale by Van Nostrand.

It is certainly an extremely rare thing for a reviewer to be called upon to notice a volume measuring but 2¼ in. by 1¾ in., yet these dimensions faithfully represent the size of the handy little book before us. The volume—which contains 80 printed pages, besides a few blank sheets for memoranda—is in fact a true pocket-book, adapted for being carried in the waistcoat pocket, and containing a far greater amount and variety of information than most people would imagine could be compressed into so small a space. The book commences with notes about excavators' work, and these are followed by others on bricklayers' work, bricks, and tiles, masons' work, the weight of stones, limes, and cements, slaters', carpenters' and plasterers' work, and various useful particulars relating to the materials employed. Then come notes on smith and foundry work, tables of the weight of bar-iron of different sections, of the weight of plates or sheets of various metals, of cast-iron pipes, and of wrought-iron bolts, wire, nails, etc. These matters are followed by rules for proportioning wheels, and various tables and data relating to the strength of materials, and after these again come memoranda relating to plumbers' work, painting, glazing, and paperhanging. Then we have a table giving the weight per cubic foot of about one hundred and fifty different substances, and a variety of data of a similar kind; besides a table of tangential angles for railway curves, regulations for railway road crossings, an epitome of mensuration, tables of circumferences and areas of circles, and tables of foreign moneys and of English and foreign weights and measures. A few memoranda relating to hydraulics, the flow of water and gas through pipes, etc., might, we think, have been added with advantage, even if some of the data at present contained in the book—such, for instance, as some of the tables of the weight of nails and of the weight of round cast-iron—had been omitted to make room for them. A few rules might also have been included in the part devoted to the strength of materials, which would have materially increased the value of the book to mechanical engineers. On the whole, however, the little volume has been compiled with considerable care and judgment, and we can cordially recommend it to our readers as a useful little pocket companion.—*Engineering.*

FIRST PRINCIPLES OF CHEMICAL PHILOSOPHY. By Prof. J. P. COOKE, Jr. Welch, Bigelow & Co. For sale by Van Nostrand.

Beginning with clear definitions of volume and weight, the simple relations which exist between them when expressed in terms of the French metrical system are pointed out. Then the advantage of the employment of the *crith* in chemical calculations. By reasoning from the phenomena of expansion on increase of temperature, it is shown that the movements of the molecules make themselves known as heat, and that the temperature of a body may be expressed by the general formula for the momentum of a moving mass, or $\frac{1}{2}mV^2$. The argument is given for assuming as one of the fundamental doctrines of the new chemistry, that equal volumes of all gases, at the same temperature and pressure, contain the same number of molecules. The way of arriving at the numbers most approximate to the true atomic weights, is stated, and the exact value of the control exercised by specific heats upon the calculation. Also the manner of computing from the symbol of a substance its percentage composition, and the way of arriving at the molecular weight of a body in the liquid or solid state by comparison with substances whose molecular weights are known. The chapter on equivalents illustrates clearly the meaning of the terms quantivalence and atomicity, and that on types the manner of representing the constitution of compounds by graphic symbols. The inorganic acids, bases, hydrates and salts are brought into harmonious relations on the new system, and a similar harmony is shown to reign among various classes of organic compounds, such as the alcohols, fats, ethers and glycols. In the chapter upon silicon some very interesting original views are presented concerning the formulæ of silicates and the method of computing them. We believe that this is the first text-book in which all the great theories of modern chemistry are systematically, clearly, and logically presented. At the outset certain broad principles are laid down with reference to the nature of atoms and their relations to the chemical and physical forces, and upon these principles, as a foundation, the phenomena of chemical science are built up into a symmetrical and imposing superstructure. The great strength of the book, however, is in the vast array of numerical problems by which the principles are illustrated. They test the knowledge of the student in every possible way, and greatly increase his power of applying it. The book is no ordinary one, but it is to be placed with those distinguished few like "Fresenius' Anaysis," "Herschel's Astronomy" and "Dana's Geology," which mark an era in the history of instruction in the sciences to which they relate.—*Journal of the Franklin Institute.*

LA FORTIFICATION IMPROVISE. Par A. BRIALMONT, Colonel d'Etat Major. Bruxelles: Micquart. 1870. 8vo., plates. For sale by Van Nostrand.

This thoroughly practical and instructive little work, by Colonel Brialmont, well known to military students as an author, and as one of the ablest and best-informed officers in the scientific corps of the Belgian army, would be well worth translating into English for the benefit of our volunteers, if not for commissioned and non-commissioned officers of the line.

It not only treats—as practically as even a contractor for earth work could desire—of the formation of field-works, but also with lucidity, and aided by many well-chosen examples, taken from military history, of the tactical and strategic capabilities and relations of field-works, and how nature and natural features are to be made to aid the shovel, and these the rifle and the sword.

LES HOUILLIERES EN 1869. Par AMEDEE BURAT, Ingenieur, etc., etc. Paris: Baudry. 1870. 1 vol. 8vo, and 1 atlas folio. For sale by Van Nostrand.

M. Burat, known to most persons engaged in coal mining by his previous able and voluminous works, descriptive of the great French coal basins, and of their colliery workings, is the secretary of the Committee of French Collieries—or, as we might say, French coal owners—and as such is the author and editor of this above-named work. Three eminent members of this committee have been removed by the hand of death during the past year, and the volume, which is dedicated by its author to their memory, commences with three interesting memoirs of the lives and careers of the deceased members, MM. Jean de Bret, De Cheppe, and S. Dubois.

The first thirty-five pages following are occupied with a subject second to none in importance to the coal industry of France, as it equally is so to that of every sort of industry in every country, namely, that of *strikes*. It is one of the most remarkable, as well as one of the most novel features in the actual social aspect of the Continent, that strikes (*grèves*), which for a long time seemed almost confined to ourselves, and to be the outcome of our rich and fluctuating profits, our ignorance, and more or less ill-feelings on the part both of employed and employers, and of our freedom, have got firmly rooted amongst the wage recipients of the Continent; and latterly appear to be by these conducted with a degree of acrimony, political admixture, and violence, which throw our own like disgracing and disordering events, quite into shadow.

We have here the circumstances and details, as well as the final consequences, told of five or six of these great French colliery strikes. We shall not attempt to analyze these in so brief a notice as we can here afford space for. The second chapter, which in some respects is the *piece de resistance* of the book, consists of clear descriptions referring to the atlas of plates of some of the most recent and noteworthy pit-work and machinery constructed for French collieries. We have here the pit-work of Providence Pit, in the Pas de Calais. The direct-acting pumping engine of Kladno, in Bohemia; the great pumping engine of Mainbourg, of 1,000-horse power; the new pumping engine for the Saint Laurent Pit at Creusot, in which there are several novelties, as well as a decided improvement in the arrangement of the ponderous balance bobs—based on purely scientific considerations; and, lastly, a detailed account of what will probably ere long be pronounced the most wonderful water-pressure engine in the world, namely, that—by this time most likely at work—under ground in the pit of Montceau les Mines. It has been designed by M. Audemar, the mechanical engineer of the colliery, and is to raise water under a pressure of about 600 metres of head. The remainder of this volume consists of the statistics of French coal output, compared with that of other States, for the year 1869; and of the legislative Acts and other public documents bearing upon colliery interests in France for the same period.—*The Engineer.*

DIE EINZEIT DER ERDE. Von ALEX. BRAUN. Berlin. 1870. Pamphlet. For sale by D. Van Nostrand.

Is one of a series of popular but good lectures on many various subjects of a philosophical or scientific class, which are published in a serial form by Virchou and Holtzendorff, of Berlin, and to which—partly on the score of merit as to the leading notions of the publication, partly on those of its cheapness and good type, though that is the eye-straining Gothic text—the gold medal was awarded at the Amsterdam Exhibition of last year. The present is the third series of this work, and comprises subjects as various and diverse as "Machiavelli," "The Exchange and Speculation," "Hospitals and Lazzarettes," "African Discovery," "Scientific Botany," etc. The part we here notice records a lecture delivered at the hall of the Singing Academy of Berlin by Herr H. Braun, with subsequent additions by the author. It is a good sparkling account of the most advanced in geological speculations, but fails wholly in pointing out the excessively small basis upon which a large part of the glacial epoch, and all that thereto belongs, has been built up, or in separating, as to it, the true from the false.

HANDBUCH DER EDELSTEINKUNDE. Von Dr. ALBRECHT SCHRAUF. 1 vol. 8 vo, with 43 woodcuts. Vienna. 1869. For sale by D. Van Nostrand.

This is as complete and clear an account of the natural position of our earth, of the physical and chemical properties, and of the characteristics, important to the traveller, of all the mineral substances used as personal ornaments, and commonly called precious stones, as we have anywhere seen.

Dr. Schrauf, who is a lecturer on mineralogy in the University of Vienna, and keeper of the royal mineral cabinet, has condensed a vast mass of information, given it accurately, and given abundant references to his authorities, for much curious historical information scattered through its pages, which embrace every ornamental stone from diamond to quartz, excluding all such as are *alone* used for architectural decorations, such as alabasters, jaspers, marbles, etc.—*The Engineer.*

FIRST LESSONS IN INORGANIC CHEMISTRY. By T. WARD, F. C. S., etc. Manchester: John Heywood. London: Simpkin, Marshall & Co. 286 pages.

There is already more than a superabundance of small text-books and manuals on chemistry; and it is a matter for wonder that, while there is no lack of really excellent books for young pupils,

so many authors rush into print, imagining that they can improve upon what exists, and evidently forgetting "*Comment fait on des livres? Avec des livres.*" Let us briefly glance at the contents of this little volume. It partakes, in its arrangement, of two excellent works - viz., Stöckhardt's well known book; and the small volume written by Professor Roscoe. We are sorry to be compelled to say that Mr. Ward's book is inferior to each of these, individually, as it is deficient in that lucid and precise clearness of exposition and soundness of definition which so eminently characterize the two works just alluded to. While we thus express our opinion, we must in all fairness also say that, as far as we have perused Mr. Ward's book we have not found therein any heteredox or incorrect statements. The book is well got up, is provided with wood-cuts, and contains some very useful tables relating to weights and measures, thermometer degrees, and a copious index. There is also added a chapter on qualitative analysis, which is, however, too brief to be of much use.—*Chemical News.*

THE PRODUCTION OF IRON AND STEEL IN ITS ECONOMIC AND SOCIAL RELATIONS. By ABRAM S. HEWITT, U. S. Commissioner.

The immense importance of the industry of which this report treats will lead to its being more widely read than the reports of either of the other Commissions.

The information contained in it is of an exceedingly valuable kind; the statistical matter is presented in a compact form, and the conclusions drawn by the thoroughly practical mind of the author are given with admirable vigor and conciseness. The second section of the report is devoted to Bessemer steel, and was prepared by Mr. Slade.

THE PROGRESS AND CONDITION OF SEVERAL DEPARTMENTS OF INDUSTRIAL CHEMISTRY. By J. LAWRENCE SMITH, U. S. Commissioner to the Paris Exposition. Washington: Government Printing Office.

The separate chapters of this report taken in their order treat of: 1st. Sulphuric Acid Manufacture. 2d. Soda and the Salts of Soda. 3d. Potash and its Compounds. 4th. Ammonia, Baryta, Magnesia, and Alumina. 5th. Chlorine, Fluorine, Manganese, and Carbonic Acid. 6th. Industrial Production of Oxygen, Hydrogen, and other elements. 7th. Gas Manufacture. 8. Stearic Acid Industry.

The report is illustrated by seven folding plates.

REPORT UPON STEAM ENGINEERING as illustrated by the Paris Universal Exposition, 1867. By WM. S. ANCHINGLOSS. Washington: Government Printing Office.

The several divisions of this valuable report treat respectively of Railway Engineering, Portable Engines, Cranes, &c.; Steam Generators, Stationary Engines, and Marine Engines.

The report covers 72 pages of well-condensed matter, illustrated by 20 woodcuts and five folding plates.

ROYAL COMMISSION ON WATER SUPPLY. 1. Report of the Commissioners. 2. Minutes of Evidence before the Commissioners. 3. Appendix to Minutes of Evidence. Presented to both houses of Parliament by command of Her Majesty. London: Eyre & Spottiswood.

The above volumes, three in number, contain many finely executed maps. As all the topics bearing on Water Supply, Distribution and Purification are thoroughly discussed by the Commission, the report cannot fail to be valuable to Engineers interested in this branch of professional labor.

FIRST ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIANA, made during the year 1869. By E. T. COX, State Geologist. Indianapolis: A. H. Connor, State Printer. For sale by Van Nostrand.

This survey includes the counties of Clay, Greene, Fountain, Warren, Franklin and Vermillion, and includes a portion of that coal area known as the Great Illinois Coal Field.

The maps which accompany the Report represent Clay, Greene and Vermillion counties. The Report dwells chiefly upon the economic geology of the area embraced in this first survey.

COMPARISON OF THE DIMENSIONS OF AMERICAN BLAST FURNACES. By T. EGGLESTON, Jr., Professor of Mineralogy and Metallurgy, School of Mines, Columbia College. For sale by Van Nostrand.

This is a pamphlet of four leaves only, containing in tabulated form the dimensions of the various parts of blast furnaces in the different States of the Union.

The statistics were collected by Professor Eggleston, who addressed circulars to iron manufacturers soliciting this kind of information.

THE NEW ELEMENTS OF HAND-RAILING, in concise problems, calculated to bring this most useful science within the reach of every capacity. By ROBERT RIDDELL. Illustrated with 40 plates. Philadelphia: Claxton, Remsen and Haffelfinger.

This book is for the practical builder only. The directions for laying out work in this branch of labor are concisely given, and the plates seem to be all that can be necessary.

NOTICE SUR L'ECLAIRAGE AUX HUILES MINERALES. Par EDMOND COLIN. Conductor des Ponts et Chaussées attaché au service des Phares. Paris: Dunod.

A work of 120 pages, with three large plates, illustrating the preparation and use of petroleum for illuminating purposes, and especially the different forms of burners which are adapted to lighthouses.

FERMETURE CYLINDRO-PRISMATIQUE. DE F. KRUPP. Pour les cannons de gros calibre. Paris: Libraire Militaire.

A pamphlet of 13 pages only; the text being devoted to the description of the five plates. The work is of undoubted value to all who are interested in heavy ordnance.

FORMULES APPROXIMATIVE DE CONSTRUCTION NAVALE. Par J. A. NORMAND. Paris: Arthur Bertrand.

A thick quarto pamphlet, illustrated by numerous wood-cuts, and containing nine large plates.

DE LA METHODE A POSTERIORI EXPERIMENTALE, ET DE LA GENERALITE DE SES APPLICATIONS. Par M. E. CHEVREUL. Paris: Dunod.

MISCELLANEOUS.

SHADING AND TINTING DRAWINGS.—From a correspondent's letter from California, we take the following valuable hint to draughtsmen:

"Every engineer has felt the difficulty of shading or tinting mechanical drawings by the usual methods. A very perfect tint may be readily obtained as follows:

"Take a small piece of fine wire cloth, about fourteen openings per inch, and a short, stiff brush. Hold the cloth over the place to be tinted or shaded and rub the brush, slightly filled with the tint, quickly across it. By continuing this process a short time a tint is formed from the minute drops which fly off from the brush by the rubbing on the wire. Thus parts of the drawings which are not to be tinted with the first color can be covered with pieces of paper, pinned to it with fine needle points, or held by paper weights; and different depths of the same tint may be had by covering the parts in succession with pieces of blank paper. The effect of drawings finished in this way is similar to that of a fine lithograph."

WHITE BRASS.—A metal bearing the above name —which is correctly applied—has recently been brought under our notice, and promises to play an important part in its application to the bearings of machinery and for other similar purposes, if, indeed, it does not do so already. This metal is the invention of Mr. P. M. Parsons, and is manufactured by him at the Thames Foundry, East Greenwich. Although somewhat similar in appearance to some of the alloys known as white metal, it nevertheless differs from them most materially in other respects, inasmuch as it is harder, stronger, and sonorous. It is, in fact, as its name indicates, a species of brass, and behaves in a similar manner to that metal under the tool when bored or turned. It does not clog the file, and is susceptible of a very high polish; at the same time its fusing point is lower than that of ordinary brass, and it can be melted in an iron ladle over an ordinary fire. These special features render the metal valuable for fitting up machinery where first cost has to be kept down, as it can be run in place for bearings, or bushes, thus avoiding the expense of fitting or boring. It can also be cast in metal moulds, or even in sand and loam, like ordinary gun-metal. Although this new metal is not very generally known, we find it to have been in use for some years past in various engine works and on several of our leading railways, where it has proved itself particularly suitable for the bearings of engines and carriages, and the wearing parts of machinery generally. Having indicated some points of resemblance existing between white brass and ordinary brass, let us now turn to the points of difference, which are very marked. Compared with gun-metal or ordinary brass, white brass is the cheapest, whilst at the same time its durability is greatly in excess of either of those metals. This latter point has been established by a series of carefully conducted experiments on the Great Northern Railway, made with carriages running in the express train between London and Edinburgh, the axles being fitted with ordinary brass bearings at one end, and white brass bearings at the other. These experiments were instituted by Mr. Sturrock, and they form the subject of a report from that gentleman, and which is now before us.

According to this report, which is dated the 20th May, 1862, it appears that two white brass bearings, fitted under a break van, lost only 2 ounces in weight in running 19,400 miles. Two ordinary brass bearings, fitted under the other end of the same van, and which travelled the same distance, lost 2 lbs. 4 oz. In another case a third-class carriage was fitted up in a similar manner, and ran 20,000 miles. Here the white metal bearings lost only 2½ oz., whilst the ordinary brass bearings lost 1 lb. 6 oz. In another third-class carriage similarly fitted, the diminution in the white metal bearings was 2½ oz., whilst in the ordinary brass bearings it was 1 lb. 12 oz. in running 20,000 miles. The bearings ran perfectly cool, and were lubricated with oil. In July, 1864, four white brass bearings were taken from a brake van which had run 64,712 miles. Mr. Sturrock reports that the bearings were still in very good order, and but little worn. After this important testimony to the value of this metal, little more, we think, can be added than that it has proved itself equally successful in bearings for general purposes. We cannot find that such a thing as a hot axle has ever been heard of where it has been used as a bearing; in fact, it seems to possess the peculiar property of lubricating itself to a certain extent when the oil or grease fails. This much is certain, that when it was adopted on the Great Northern Railway, the stoppage of the long express train from London to Edinburgh from hot axles entirely ceased, although stoppages from this cause had previously been of constant occurrence. It would seem to us that the knowledge of such facts as we have here before us, is all that is required to render the use of white brass general.

THE BEST FORM OF CHOPPING-AXES.—If nothing were required of an axe more than to simply sever the grain of wood by cutting the fibres in twain, the form of bit to operate with the greatest efficiency would be that of a thin tapering wedge. But since the bit has another office to perform, namely, the removal of the chips, that part of the instrument near the cutting edge must be ground to the most effective form for "chipping well." After the bit of a chopping-axe has been thrust into wood one or two inches, the cutting edge can not be forced the same distance further, at the next blow, unless the chip that has been cut off be lifted or thrown out of the kerf. Were the bit of a chopping-axe ground off true, like an iron wedge, the chopper would be obliged to exert as much strength to withdraw his axe from the wood as was required to drive the edge into the timber. For this reason, the bit at one and two inches from the cutting edge is made thicker midway between the front and rear side edges, for the purpose of splitting every chip that is cut off. Then the two flat sides of the blade, from the cutting edge toward the eye, instead of being dressed to a true taper, are ground somewhat circular, so as to be of the most efficient form to raise the chip as fast as the wood is cut off. These suggestions furnish a philosophical reason for making the bits of chopping-axes of the peculiar form which they receive at the hands of the manufacturer.

It is not practicable to convey to the reader a correct idea of the most efficient form of a chopping-axe, except by an oral explanation with an axe in hand, to illustrate points that can not be committed to paper. An intelligent chopper, if he will exercise a little thought on the subject, will per-

ceive at a glance, what form of bit will enter the wood deepest, and at the same time lift the outside chip from the kerf when the instrument is wielded with a given force.

Another important point in the form of the cutting edge is its curvature from the front to the rear corner. When the bit at the cutting edge is made almost straight from corner to corner, a chopper will be able to chop faster, and make less "mince meat" of small chips, and leave the ends of the logs smoother, than if the cutting edge were made of a more circular form. Most axes that are now manufactured have almost no corners at the cutting edge, the bit being formed with as short a curve as an old-fashioned chopping-knife—nearly circular. When the bit of an axe is made of such a form, it will seem to enter the timber further, at a given blow, than if the cutting-edge were nearly straight; and the central portion is actually driven deeper into the timber than if the cutting edge were nearly straight. But a portion of the cut is really of no account, as the outer chip was not lifted.

When scoring timber, it is of eminent importance that the cutting edge of the axe should be nearly straight from corner to corner. Otherwise, the face of the hewed stick will appear badly hacked with deep cuts beyond the line, which will always be the case when scorers employ axes with circular edges. Many a skilful scorer has used an old axe with the corners ground off, and has exercised great skill in endeavoring to cut only to the line. But after the hewer had dressed off the side of a stick, splitting the line with his broad-axe, the work of the skilful scorer would then show that the scoring had been done in a very unsatisfactory manner, simply because the form of the cutting edge of the axe was not correct.—*Manufacturer and Builder.*

Mining Tools from Sinai.—At a recent meeting of the Manchester Literary and Philosophical Society, Mr. William Boyd Dawkins, F. R. S., exhibited some old mining tools, brought over by Mr. Bauerman from the turquoise mines of the promontory of Sinai, consisting of a stone hammer and rude splinters of flint. The turquoises occur in a bed of a quartzose mottled sandstone in Wady Sidreh and Wady Maghara, in joints running for the most part north and south. They were worked, according to the evidence of the hieroglyphic inscriptions on the rock, by the Egyptians from the third to the thirteenth of the dynasties mentioned by Manetho. In and around the workings there are still the tools with which they were carried on. Innumerable splinters of flint, with their points blunted and rounded by use; stone hammers, some of which are broken; and round pebbles with a concavity on either side caused by the friction of the thumb and finger charged with particles of sand, and segments of small wooden cylinders, lie together. The flint flakes exactly coincide with the grooves in the rock made in the excavation, and evidently have been blunted by such use. The fragments of wooden cylinders are believed by Mr. Bauerman to have been portions of the sockets into which the flakes were fitted. The round pebbles were probably used for driving the rude chisel formed by the flint inserted into the wooden socket, while the large stone hammers were used for breaking up the rock. There was no evidence that metal of any kind was used in the work. Mr. Bauerman also satisfied himself that the hieroglyphs were cut with implements similar to those used in the mining. This discovery is very important, because it opens up the question as to what tools the Egyptians used in working their wonderful monuments of granite and syenite. If it were worth their while to conduct turquoise mining with flint flakes in the Sinaitic promontory, and if they used the same tools in the hieroglyphs that fix the date of these mines—and of this there can be no reasonable doubt—it is very probable that they employed the same means for the same end elsewhere, and that, to say the least, a part of their marvellously minute sculpture in Egypt has also been wrought with flint. There is no evidence that they were acquainted with the use of steel. Iron and bronze are not hard enough for the purpose. The minute and delicate sculpture left behind by the Mexicans, which can be proved to have been worked with stone tools, adds to the probability of this view.—*Mechanics' Magazine.*

Rouget's Fixative Process.—In the month of March of last year Prof. Rouget, one of the Masters in the Government Schools of Paris, made a discovery, which in its effects will be invaluable to artists and the art world in general; indeed, it appears to us that this useful invention requires only to be known to be at once fully appreciated, and we gladly take this opportunity of mentioning it to our various readers. It is a rapid and apparently perfectly safe method of fixing chalk, charcoal, crayon or pencil drawings, by means of a particular fluid blown through a glass siphon in the form of a fine spray, on to the material to be fixed. The paper on which the drawing is made is not injured by the fluid; on the contrary, it is preserved by it—in fact, one of the great uses of this fixative process is supposed to be the preserving of the paper and color of water color or other drawings from decay. The apparatus is in itself of a very simple character, a child might learn to use it, and it is likewise very portable. The process has been warmly taken up by many distinguished French painters, architects, and draughtsmen; amongst them, we may mention Gerome, Cabanel, Villems, Gleyre, Viollet-le-Duc, and Gustave Doré; it has also been used by some well-known artists in this country, and they have expressed themselves well satisfied with the results. It was tried this summer on a crayon sketch of a sunset, and the glowing colors were not in the least injured. This is an example of the undoubted benefit of this process to the painter, for with its aid he may rapidly draw in sunset effects, with that most rapid of mediums, colored crayons, and keep them by him as studies for ever, as bright and uninjured as when first executed. There is another agreeable quality in this process: when the drawing has been fixed, is is quite easy to work upon it again and again, providing only that the parts worked upon be finally blown over with the spray when the drawing is quite finished. Architects will find this apparatus most useful in fixing their rough pencil sketches and more elaborate drawings of architectural details. The very simple rules for using Prof. Rouget's process are sent with it, packed altogether in a neat little box. The London agents for the apparatus are Messrs. Corbière, 30 Cannon street.—*The Building News.*

An Asbestos Air Filter—Manganese and some Alloys of it—Results of Carbonizing Wood

IN VARIOUS VAPORS.—A very good suggestion for an air filter, equally applicable for a ventilator or a respirator, is made by M. Woestyn, who proposes to place in a ventilating shaft a bag of asbestos. This, like cotton, will arrest any solid particles floating in the air, and when much soiled, the asbestos can be removed and made white hot, by which all organic matters will be destroyed, and it may then be put back in the shaft again. For respirators, asbestos would be far preferable to the cotton wool proposed by Dr. Tyndall. It would not hold moisture like the wool, and would at the same time be most efficacious as a filter; and made so that the asbestos could be easily removed to be burnt and put back again, they might come into use and be highly recommended. There would be obvious difficulties in the way of effectually filtering the air admitted to a large building, but we agree with M. Dumas in considering that the suggestion of M. Woestyn is worthy of serious attention.

Manganese, we fear, will never be a cheap metal, and alone would seem to be susceptible of no useful application; but we learn from the researches of M. Valenciennes that it forms very beautiful and useful alloys with copper. One in particular, containing only 15 per cent. of manganese, is almost white, and in many of its properties greatly resembles steel. Other compounds form, we are told, superb bronzes. How far these may be capable of replacing our ordinary bronze it would be prema ture to speculate in the present undeveloped state of the industry of manganese. The same metallurgist we have mentioned above has procured pure cobalt, which seems to be a metal that may some day be usefully applied.

People sometimes do odd things and arrive at strange and unexpected results. What M. Sidot was driving at when he carbonized wood in the vapor of sulphide of carbon we cannot imagine; but it ended in his obtaining charcoal, which, when struck, is as sonorous as a piece of metal. He then got a bell turned in wood, carbonized it in the same way, and has an instrument which gives a sound like that of a silver bell. The carbonization is only superficial, and possibly the bell may not be very brittle, as it certainly would be if it were complete. Besides sulphide of carbon, the author calcined wood in the vapor of wood spirit, and so obtained a fibrous coke of silky whiteness. This is a very curious result; white coke is a novelty, and it would be interesting to know for certain what does happen when wood is heated to a carbonizing temperature in the vapor of wood spirit.—*Mechanics' Magazine.*

TIN IN CALIFORNIA.—The Philadelphia "Railroad and Mining Register" says: It has long been a desideratum to find this metal in America. In the Old World and in ancient times the alloy of this metal with copper supplied the place of iron and steel. Egypt probably owed to it the erection of its mighty edifices, not only before, but long after the communication was opened between the valley of the Nile and the highlands of Armenia and Persia. Even after the consolidation and extension of the Roman Empire in the iron producing regions of Asia, Spain and Britain, the Roman legions were armed with offensive weapons of iron, but with defensive armor of bronze. England owed her first important influence upon the civilized world to the tin mines of Cornwall. Where the Peruvians got their copper-tin alloy from is not well known, but they had hit upon its proper constitution before the appearance of their Spanish conquerors. Tin was an American mineral. Nevertheless, it was found impossible to open mines of it anywhere this side of the Atlantic, worth the pains. The discovery of a few thin veins by Dr. Jackson, in the White Mountains, and of crystals of tin ore here and there in various other parts of the United States, was heralded with great enthusiasm, but resulted in no benefit to the arts. Within a year or two traces of tin discovered in Missouri gave rise to much speculation, some of it of a rather dishonorable character. Ores of tin from that State proved to contain, either the smallest percentage possible, or none at all. But at last some genuine and rich tin ores have come to light, and are authenticated by the highest authority we have at hand, as the following letter from Dr. A. R. Roessler, the learned and efficient mineralogist of the United States General Land Office, Cabinet of Practical Geology and Mining, at the Capital, to the editor of the "Franklin Institute Journal," will show:

SIR,—It will be remembered that an exposition of the agricultural, manufacturing and mineral resources of California was held last year at San Francisco, at which were exhibited the unmistakable evidence of the existence of the metal tin in California. Sacks of ore, bars of tin plate, of the heaviest quality, and utensils of every sort for domestic use which were manufactured from it, were there collected. There were many who doubted and shook their heads at this display of a long desired but unusual manifestation of riches. The days of humbug were not yet over. Gold and silver, quicksilver and platinum, and many other more common metals in any quantity, they should believe in; but the metal tin, so valuable and found in so few localities in the world, was a demand on their credulity not to be honored. This uncertainty has become, not a dead, but a living certainty. Additional information and additional specimens of ore have been forwarded to this office, and an average sample of the same has been submitted for analysis to the able and distinguished chemist and mineralogist, Dr. F. A. Genth, who reports that it contains 13.37 per cent. of tin. The black mineral in the ore is tourmaline (it contains boracic acid) and the brownish red is the casiterite. It is a highly interesting occurrence, and the yield of tin is almost twice as much as the usual working ores of the tin mines of Cornwall, England. The property is said to consist of 50,000 acres of mining lands, and over 20 openings have been effected, from all of which the ore is extracted. The finding of this important metal in California may be regarded as the last crowning act which was required to place California in advance of all the world for mineral wealth.

Respectfully,

A. R. ROESSLER.

—*Iron Age.*

A very easy way of detecting logwood color in wine has been published in France, which, if good for anything, will be useful in discovering the adulteration of port. We have only to moisten a strip of paper with a strong solution of neutral acetate of copper, and dip it into the suspected vinous fluid, which, if it contains logwood, will give a blue color to the paper. If, however, the color of the wine be the natural product of the grape, the paper changes to a gray shade.